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U. S. DEPARTMENT OF AGRICULTURE.

WEATHER BUREAU.

BULLETIN No. 32.

HURRICANES:

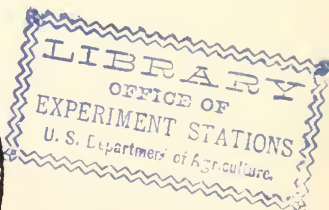
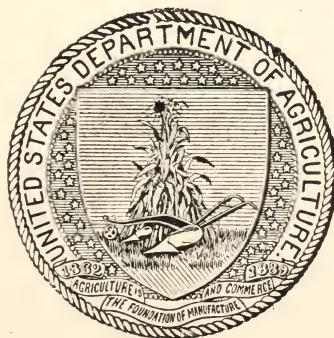
ESPECIALLY THOSE OF PORTO RICO AND
ST. KITTS.

BY

WILLIAM H. ALEXANDER,

Observer, Weather Bureau.

Prepared by direction of WILLIS L. MOORE, Chief of the United States Weather Bureau.



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1902.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF CHIEF OF U. S. WEATHER BUREAU,

Washington, D. C., January 11, 1902.

HON. JAMES WILSON,

Secretary of Agriculture.

SIR: I have the honor to submit herewith the manuscript of a paper entitled "Hurricanes, especially those of Porto Rico and St. Kitts," by Wm. H. Alexander, observer, United States Weather Bureau, and to recommend its publication as a bulletin of the Weather Bureau.

This paper has been prepared by my direction in the belief that it will be useful and instructive to the inhabitants of Porto Rico. Mr. Alexander has distinguished himself by his activity in studying the climatology of that region, and the data collected in this paper are undoubtedly as reliable as it is practicable to make them.

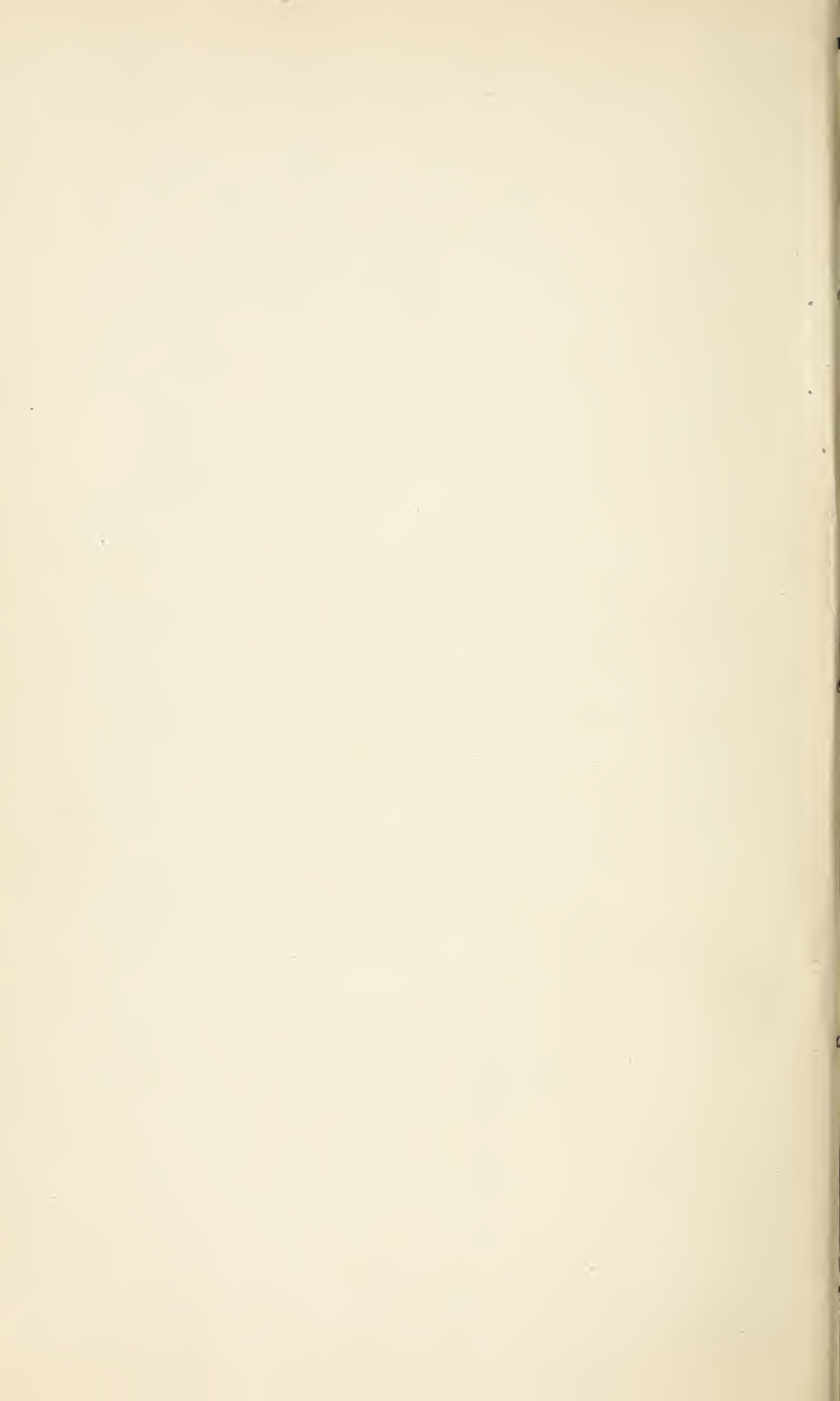
Very respectfully,

WILLIS L. MOORE,

Chief United States Weather Bureau.

Approved.

JAMES WILSON, *Secretary.*



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INTRODUCTION.

The atmosphere is one of the most fruitful fields of research in the whole domain of modern scientific investigation. No relation could be more intimate than that which exists between the air and all forms of life upon the earth. It should therefore be our ambition to so study the physical conditions, the movements, functions, and laws controlling the phenomena of the atmosphere that we may arrive at an intelligent appreciation of the forces that preside over the changes of the weather and the seasons and that dominate the very existence of mankind. In recognition of an awakening public interest, governments and institutions of learning have in recent years expended large sums of money to facilitate investigations along these lines. The possibilities of this new field of study have attracted to it some of the master minds of the age, who have devoted their energies to systematizing and advancing our knowledge, and to-day we find meteorology not only recognized as a science, but as one of unquestioned practical value, commanding respect and attention from thinking minds everywhere. We no longer regard the atmosphere as a region of mystery and lawlessness, but we look upon every atmospheric phenomenon as a result of laws as uniform and inexorable in their operation as those that bring the apple to the ground or guide the planet in its orbit. Where may we find lessons more practical or more suggestive, problems more interesting or more complex, manifestations more beautiful or more sublime than in the study of meteorology? The subject is vast, and our interest in it is direct and permanent, as well as real and universal, for truly "*in ea vivimus, movemur et sumus.*"

The following pages are devoted to a brief consideration of a single phase of this vast subject, viz. those frightful atmospheric disturbances commonly known as hurricanes, which develop to gigantic proportions and cause appalling destruction of life and property.

Tropical hurricanes occur at certain seasons of the year in the Phillipines, East Indies, China Sea, the Indian Ocean, and the West Indies; they move thence into adjacent parts of the earth, but the greater part of the globe is practically free from their visitations. There is a similarity more or less distinct in the geographical features of these well-known hurricane regions which is worthy of study. Each has on the west a large continent, the coast line of which extends more or less nearly from north to south, is indented by gulfs and bays, and

has to the east of it a vast sea containing numerous islands. "But of all the cyclonic regions," says Dr. Viñes, "within the intertropical zone the one which more perfectly and grandly combines all these conditions is the great 'Bay of North America,' with the wide Atlantic Ocean extending to the east as far as the coast of Africa and to the northeast as far as the coast of Europe and the northern seas. In my opinion, this contributes much to the grandeur and regularity of the immense paths of the West Indian cyclones (hurricanes)."

The hurricanes, or typhoons, of the China Sea may occur at any time from July to November; they usually begin east of the Philippine Islands and move first in a direction between west-northwest and west-southwest.

The region known as the Indian Ocean extends on both sides of the equator, and may very properly be said to embrace two hurricane regions, one on the north and one on the south side of the equator. So far as known, however, no hurricane ever moved across the equator. They may occur, and in fact have occurred, on the same meridian at the same time, but on opposite sides of the equator. The region north of the equator has two hurricane seasons, one in April and May and the other in October and November. South of the equator, in the Indian Ocean, hurricanes occur from January to April; these usually originate at about 10 degrees south latitude, move to the west-southwest until south of Mauritius, then take a more southerly course, and when about 28 degrees south their paths recurve to the southeast.

The hurricane season of the West Indies begins annually about the middle of June and lasts until the first of November. The origins, movements, and physical features of these West Indian hurricanes are the subjects of the following discussion, the aim being to present the facts in such a brief, simple manner as to enable one to get a correct knowledge of the essential characteristics and the most prominent laws relative to these storms.

In the preparation of this paper frequent reference has been made to the following publications: *Physics*, by Watson; *Elementary Meteorology*, by Waldo; *The Atmosphere*, by Flammarion; *Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes*, by Viñes; *West Indian Hurricanes*, by Garriott; *Handbook of the Hurricane Season*, by Westerby; *Chronological History of the West Indies*, by Southey; *History of the West Indies*, by B. Edwards.

This memoir was originally prepared in 1899 and submitted for publication early in 1900: portions of it were quoted in the general memoir on West Indian hurricanes by Prof. E. B. Garriott, (*W. B. Bulletin H.*). It was then referred back to me, with instructions to prepare a special memoir on the hurricanes of St. Kitts and Porto Rico for distribution in those islands. The present manuscript has been revised by Professor Abbe, who has also read the proof sheets.

CHAPTER I.

THEORIES AS TO THE ORIGIN AND MOVEMENT OF ROTARY STORMS.

Unfortunately many of the terms used to designate the various kinds of atmospheric disturbances are not used with all the precision that is essential to clear conceptions and logical thought. This loose, indiscriminate use of terms leads to confusion in the public mind, resulting in a depreciation of the real practical value of our existing knowledge on this subject and of the efforts at advancement along this line. In view of this fact, therefore, we will first explain certain terms as they are now understood and generally used in the official publications of the United States Weather Bureau and as they will be used in this Bulletin.

1. *Cyclone* (Greek *Κυκλος*, a circle).—This term was originally applied to the circular movements assumed in connection with the old “law of storms,” but as now generally used it is applied to all kinds of atmospheric disturbances characterized by an area of low barometer about which there is a movement of the air inward spirally toward the center. It is applied equally to severe hurricanes and typhoons and to the general areas of low pressure or the barometric disturbances of slight intensity but of vast proportions, whose diameters vary from several hundred miles to a thousand or more. These latter disturbances properly belong to the temperate zone and occur at all seasons of the year, being decidedly more vigorous in winter than in summer. They enter the Pacific coast of the United States from the northwest or southwest, and crossing by well-known paths make their exit in the vicinity of the Gulf of St. Lawrence. The value of the general weather forecasts for Canada and the United States depends very largely upon a correct analysis of the nature and relation of the various forces involved in these storms.

2. *Hurricanes, typhoons, or baguios*.—These are often called tropical storms, but are more correctly storms of intertropical origin and are sufficiently distinctive and are certainly of sufficient importance to entitle them to retain their distinctive names. Those originating in the Atlantic and passing over the West Indies or near the Atlantic coast of North America, or over the Caribbean Sea and Gulf of Mexico,

have received the name of hurricanes. Those visiting the Pacific, the East Indies, the Indian Ocean, and the coasts of Asia are known by the name of typhoons. The Malay term *baguios*, as used in the Philippines, is also now recognized. These storms are essentially the same as regards the manner of formation, movements, and general physical features, the only significance attaching to the different names is geographical. These names come down to us from the distant past and possess an historical value which alone entitles them to a permanent place in meteorological literature, and if used consistently, as above suggested, no better terms need be desired. The term *cyclone* can be used as a general name for all whirling storms.

3. *Tornadoes*.—The term *tornado*, when properly used in the United States, applies only to a very small whirling storm, but one that is intensely violent and destructive. In fact, tornadoes are dreaded in the United States even more than hurricanes, as they are more dangerous and more numerous, although of far less extent. They occur in all parts of the region east of the Rocky Mountains during the spring and summer months, and occasionally in the Southern States during the winter months also. A waterspout at sea is analogous to a tornado on land but is usually far less violent, still it is much dreaded by sailors. It may sometimes happen that one cloud will produce at the same time a number of tornadoes or waterspouts. It has been noted that as a great cyclonic area sweeps across the United States, especially after it passes the Rocky Mountains, the conditions prevailing in the southeastern quadrant of the cyclone are most favorable for the formation of tornadoes. The onward or progressive movement of the tornado is very small as compared with the speed of the winds that constitute the whirl.

ORIGIN OF THE WEST INDIAN HURRICANE.

Meteorologists have not yet arrived at a point where they can satisfactorily answer every question as to how, when, and where the West Indian hurricane originates, but enough is positively known to entitle their views for all practical purposes to the fullest confidence. The usual order of advance along any line of human learning is first the ideal or theoretical and then the real; so, in a review of efforts along this line we find a number of hypotheses being advanced only to give way under subsequent tests and fuller investigation. And yet each had its use and purpose and was a step in the right direction. As facilities for the study of these phenomena are multiplied and improved our present theories will eventually be freed from any erroneous elements that they may have. For the present, then, attention is invited to the following statements as to time, place, and manner of occurrence of hurricanes. It is confidently believed that these statements rest upon the best authority and may be generally accepted as true.

(a) *As to time.*—The hurricane season—that is, the period during which hurricanes may occur in the West Indies, is generally recognized as extending from June to October, both months inclusive; the other months of the year are practically free from these visitations. The following table, quoted from Mr. Francis Watts, presents the relative frequency of West Indian hurricanes in the months constituting the hurricane season, viz:

June	1
July.....	4
August	10
September.....	8
October.....	7

Thus it appears that the month of August is the month of maximum activity in the formation of hurricanes, closely followed by the months of September and October. This suggests that a thorough study of the conditions obtaining during these months over the North Atlantic, the Caribbean Sea, and the Gulf of Mexico may furnish a partial explanation of questions relative to the origin of these storms. For instance, in August we find the great anticyclone of the Atlantic central between latitudes 30° and 35° north, and an area of low pressure is near the Cape Verde Islands. The doldrums of the Atlantic—an equatorial region marked by frequent calms—reach the northern limit of their journey during the months of August and September. Whether hurricanes shall occur in June or July seems to depend upon the extent to which the anticyclone of the Atlantic encroaches upon the Caribbean Sea. If the Caribbean Sea is only to a slight extent under the influence of the anticyclone, hurricanes may occur in those months; but if the anticyclone impinges upon the lower latitudes, hurricanes during these months are very improbable. It appears, then, that the movement of the anticyclone of the Atlantic is an important, not to say determining factor in the formation and movements of the West Indian hurricane.

(b) *As to place.*—All West Indian hurricanes do not originate in the same place. Of course they all form below the Tropic of Cancer, most probably between 5° and 15° north, but the longitude of the point of origin seems to be determined by certain influences which vary with the seasons. For example, the positions of the Atlantic anticyclone and that of the doldrums determine very largely whether the hurricane forms in the Caribbean Sea or near the Cape Verde Islands. Hence we find that if a hurricane occurs in June it usually forms in the western portion of the Caribbean Sea; the July hurricanes form in the middle or eastern portion of the Caribbean Sea, while the August hurricanes form anywhere in the Atlantic between the Lesser Antilles and the Cape Verde Islands. In other words, the point of origin of the West Indian hurricane appears to move eastward as the

season advances, from the extreme western portion of the Caribbean Sea to the Cape Verde Islands. There is clearly an intimate connection between the eastward drift of the point of origin and the eastward drift of the Atlantic area of high pressure (anticyclone), as both occur at or about the same time. Another point worthy of note is that by the middle of August this region favorable to hurricane formation coincides with the doldrums on their northward journey, thus intensifying the forces at work in the formation of hurricanes. This eastward movement of the point of origin continues for about half the hurricane season; that is, from June to the middle of August. After that date there seems to be a return or westward drift along the same latitudes. Hence we find a marked similarity between the hurricanes occurring early in June and those of the latter part of October; those of the last of June and those of early October; those of July and those of September. This is particularly noticeable when we come to investigate the paths of the hurricanes for the different portions of the season. Therefore with the learned Viñes we conclude—

* * * according to the position occupied by the equatorial zone of calms, by the Atlantic anticyclone, and consequently by the southern limit of the trade winds, respectively, the cyclone (hurricane) forms either more to the north or more to the south, and, above all, more to the east or west. The point of origin and formation of the hurricanes depend, therefore, on the more or less advanced season of the year.

(c) *As to manner of occurrence.*—The “convectioal theory” of the origin of tropical storms, although it has not reached the point of direct demonstration, appears to be most reasonable. This theory may be stated as follows: A certain region within the Tropics marked by a uniform barometric pressure becomes rather warmer or moister than the surrounding neighborhood; the air over this region, because of its heat and moisture, becomes specifically lighter; in obedience to the principles of the convection of gases the lighter air has an upward tendency or buoyancy by reason of which a vertical circulation or overturning of the air occurs. The ascending warm moist air rises and overflows the colder surrounding air, producing an increased pressure at the surface of the ground in the region surrounding the heated region which contributes to the further inward flow toward the warm central area where the air pressure has been diminished by the overflow aloft. The inflowing currents at the surface and the outflowing currents above are connected by ascending currents over the heated region and descending currents on the outer boundary, thus forming a complete circuit. If these conditions were to occur on a very limited scale, or on a motionless body, the currents might flow directly inward below and outward above; but extending as these currents do over hundreds of miles and on the rotating earth they are deflected by centrifugal force to the right (in the Northern Hemisphere) thus giving them a curvilinear motion, so that the lower currents approach the

center of the heated region in spirals. This is now the hurricane in its incipency. Nor must it be thought that this work of preparation is the work of one day, but rather of many days. Day after day the air remains in ominous quietude over the watery surface of the ocean, becoming warmer and moister, gathering strength for its awful devastating career, while the watery vapor by diffusion and convection rises higher and higher until a large volume of air is almost saturated and very warm. Dense cumulus clouds are rapidly formed from which torrents of rain frequently fall. The air pressure continues to slowly decrease until at last the steadily increasing creep of the surface winds inward is followed by an overflow above; the movements are gentle at first, but increase until there is formed a violent whirl near the center.

The force of gravity and the deflective force due to the rotation of the earth are the two forces or factors in the formation of the whirl

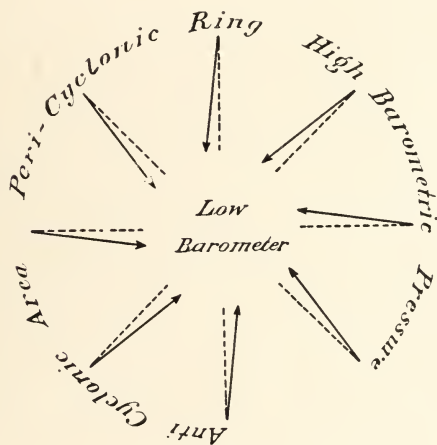


FIG. 1.

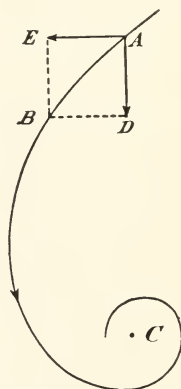


FIG. 2.

of winds, and to make as clear as possible the operation of these two forces, attention is invited to a study of figs. 1 and 2. Fig. 1 is intended to show especially the early stages in the development of the hurricane. At the center of this figure, let it be supposed, is the area of warm moist air, of gradually diminishing pressure, of decreasing cloudiness, and of heavy rainfall; in short, the future storm center. On the outside is the anticyclone of Galton or the pericyclonic ring of Ferrel, or the area of high pressure of the daily weather map. Now, as the pressure over this outer ring is greater than at the center, there must of necessity be a movement from the outer to the inner region just as certainly as water will flow from a higher to a lower level. If the earth were stationary this inward flow would take place along direct radial lines or the dotted lines in fig. 1. But according to Ferrel's great law a body moving along the surface of the earth in

the Northern Hemisphere is deflected to the right by a pressure due to its rotation around the earth's axis as compared with the rotation of the points on the earth's surface over which it passes; hence we find the air moving along paths represented by the arrows in fig. 1. It appears at once from this figure that this deflective action will result in a gyration of the air involved in a storm about some central point. The deflecting pressure increases from the equator where it is zero, to the poles where it is a maximum; hence the statement that the region of formation of a cyclone must necessarily be so far north or south of the equator that this deflective force may become effective. It is scarcely necessary to point out that the greater the difference between the barometric pressure at the center and that in the pericyclonic ring, the more rapidly these inflowing currents must move.

Fig. 2 is a modification of fig. 56 in the *Elementary Meteorology* of Prof. William M. Davis, page 89, and is very helpful in this connection. In fig. 2 the resultant motion AB is resolved into its two component motions, represented by AD and AE . The former (AD) is the motion due to the gradient of pressure surrounding the storm center; it pushes the air inward toward the region of lowest pressure. The latter (AE) is due to the deflection attending any motion on the rotating earth. At a certain distance from the center (C) these two motions may possibly be nearly or quite equal in value, but as the center is approached the radial movement (AD) diminishes and the circumferential (AE) increases, so that the radius (CA) sweeps over equal areas in equal times in conformity to the law of conservation of areas. It is the circumferential motion that gives to the hurricane its destructive winds, as the radial movement alone would rarely if ever attain dangerous velocities. An air particle trying to move from A to C must, therefore, follow a spiral path around the center, rapidly increasing its velocity as the center is approached, so that eventually it whirls around the center without ever reaching it.

The following extract from page 198 of Davis's *Elementary Meteorology* is appropriate in this place.

The origin of tropical cyclones thus appears to be well worked out. Being of convectional nature, they are not formed in the steadily moving trades, but only when the trades weaken in the loitering doldrums, where the lower air becomes excessively warm and moist. Being essentially whirling storms, they can not develop when the doldrums are close to the equator, where the inflowing currents are not required to unite in forming a systematic vortex, but only when convectional action begins at some distance north or south of the equator. The definite and rational association of these various conditions of storm growth gives warrant for much confidence in the convectional theory of the formation of tropical cyclones.

The correctness of this theory seems to be confirmed by the following facts, viz:

(1) All hurricanes originate during the season and in the region of high temperature.

(2) Copious condensation of water vapor attends their formation.

(3) An ascending current is indicated by the great cumulus cloud masses and the outflowing cirrus plumes and the drenching rains.

(4) Hurricanes behave in almost every particular just as one would expect from a study of convectional processes on a rotating body.

(5) Two seasons of violent storms occur in the Bay of Bengal; one when the sun moves northward and another when it returns southward.

(6) Hurricanes seem to originate only at places so far north or south of the equator that the earth's motion can impart a decided curvilinear motion to the inflowing currents of air.

(7) All features of the "eye of the storm" may be explained by this theory.

The full effect of the presence of moisture in the atmosphere during the formation and progress of tropical storms is perhaps not yet fully understood, but that it has a very powerful and important influence is certain. This is evident from the fact that these storms originate only in regions of very moist air, and are, as a rule, attended by torrential rains. It seems probable that the influence of the moisture is most potent after the vapor is condensed to cloud and rain, as, by the liberation of its latent heat, it then retards the cooling of the air and thereby prolongs the state of unstable equilibrium and so forces the currents to greater and greater heights. By catching all the sun's heat on the upper surface of a cloud the unstable equilibrium is intensified. This also partially accounts for the enormous quantity of energy involved in the formation and movement of these storms. We quote again from Professor Davis, *Elementary Meteorology*, page 200:

In order to realize the enormous amount of energy needed to develop a tropical cyclone we may quote a comparison that has been drawn between such a storm and a large ocean steamer. The air in a cyclone 100 miles in diameter and a mile high weighs as much as half a million 6,000-ton ships, and yet this enormous mass is set in rapid motion, averaging over 40 miles an hour, in the course of a few days and its motion may be continued for a week or more. Again the Cuban hurricane of October 5 to 7, 1844, is calculated on a very moderate estimate to have worked during the three days of its progress along our southern coast with an energy of at least 473,000,000 horsepower. The continued maintenance of so enormously powerful a disturbance calls for the rapid supply of a vast amount of energy, just as the active steaming of a large engine calls for a plentiful supply of coal under its boilers. In the case of a fully developed tropical cyclone it is believed that the energy is chiefly supplied from the latent heat of the heavy rainfall; and reasonable estimates of the amount of condensation within the storm disk show that this source of energy is ample in amount.

There have been those who held that hurricanes have an electrical origin; that electricity in some mysterious way produced the rotary movement of the atmosphere; but just how this was done no man could tell. This hypothesis has few if any advocates at the present time. The electrical displays which frequently attend the hurricane and give to it its awful appearance are to be regarded as unimportant

concomitants, possibly even accidental rather than essential important characteristics.

It has been urged that hurricanes may be considered as whirls formed mechanically between north and south or east and west winds flowing past each other. But such whirls die away unless there be a continued supply of energy—such as is afforded by sunshine, by the latent heat evolved in forming cloud and rain and by the rotation of the earth.

(d) *Structure of the hurricane.*—So much, then, for the origin of the hurricane. Let us now see what we are to understand to be the structure of a perfectly formed hurricane. On this point attention is invited to the words of Father Viñes, as found in his memoir in Bulletin No. 11, United States Weather Bureau, and reprinted on page 7, United States Weather Bureau Bulletin No. 168, and again on pages 8 and 9, Bulletin H (W. B. No. 232), together with Professor Garriott's comments thereon. Father Viñes says:

The aerial currents in a cyclone constitute a vast whirlwind around a central space of calm, of relatively small extent, called the "vortex" of the cyclone. It is an established fact that the direction of the rotary motion is always alike in the same hemisphere (northern or southern). In our own the cyclonic rotation is invariably from right to left, in the direction from east to north to west to south, or, as commonly expressed, in a contrary direction to that of the hands of a watch placed upon a horizontal plane, face upward. In the Southern Hemisphere the cyclonic rotation follows an opposite direction.

In the West Indian cyclones the rotation and the cyclonic circulation take place in such a manner that the inferior currents, as a rule, converge more or less toward the vortex; at a certain altitude the currents follow a nearly circular course, and higher still their course is divergent. It is particularly to be noted that this divergence is all the greater as the currents occupy higher altitudes until a point is reached where the highest cirrus clouds seem to move in a completely divergent radial direction.

Professor Garriott says:

The writer is prompted to question the accuracy of the conclusion of Father Viñes regarding a divergent radial direction of cyclonic currents in high altitudes. That the lower currents converge toward the vortex is an established fact; that the high upper currents have a divergent radial direction has not been established. Upper air cyclonic observations have been made only through an observance of cloud forms and cloud movements. These observations have shown that the different forms of cirrus clouds are carried by the controlling upper main current to the front, or in advance, of a cyclone; they have not shown that the clouds are projected back from the vortex. As a matter of fact the vortex acts as a chimney for the inflowing lower currents, and the moisture of these currents, which is condensed into cirrus clouds in high altitudes, is carried forward like smoke which emerges from the top of a chimney.

On page 12 of Bulletin H we find the following description by Dr. Enrique del Monte:

What a cyclone means.—Before entering upon the description of the phases above referred to, we will say something about what may be called the structure of a cyclone.

What is a cyclone, aside from its origin?—The cyclone, and especially the tropical cyclone is characterized by a vast eddy, on an average 300 miles in diameter, of extraordinary violence in the gusts of wind (90 miles per hour, and sometimes more) and carrying, necessarily, with it a relative vacuum, which increases from the periphery to the center or vortex. This rarefaction of the air in so large an area implies a lack of equilibrium in the atmosphere, which, by the law of compensations, represents an excess of air in one or more isolated places surrounding the hurricane.

Therefore, if we suppose the barometer (which is only a delicate balance enabling us to weigh the atmosphere at any moment) to be situated in any place between the periphery and the center or vortex of the eddy, the nearer it is to the vortex the lower its column will be.

On the other hand, let us suppose the barometer situated beyond the body of the hurricane, but as near as it can be without the observer being able to perceive any sign of the storm, where, in compensation for the relative vacuum that makes an integral part of the neighboring hurricane, there will be, as stated above, an excess of air; consequently, the barometer will rise more or less, but higher than the normal, and in some places it reaches an extraordinary maximum.

The above-cited affirmation that the hurricane is characterized by a relative vacuum seems a paradox at first, since the testimony of our senses tends to show to us the contrary, in the unusual impetuosity of the winds, to such an extent that the existence of a hurricane is physically impossible without the wind having at least the velocity of a strong gale. This contradiction disappears if we have in mind what the wind means. In fact, the wind is only a mass of air that flows with more or less violence to the place at which, by any cause, a relative vacuum has been formed. From the gentle breeze, moving 2 miles an hour, to the furious gale, running 100 miles, all the wind velocities are subordinate to the above-cited general cause.

In order to explain to ourselves graphically the physical reason existing between the velocity of a gentle breeze and that of the furious gusts in a tropical hurricane, let us suppose an extent of ground 60 miles long, and let us suppose, too, five observers, provided with standard barometers and situated 12 miles apart, respectively. Now, let them take simultaneous observations at a preconceived hour (10 o'clock a. m., for instance), and correct them for temperature and elevation. Everyday experience demonstrates that the larger the difference between the readings of the barometers at the stations, the greater is the velocity of the wind at that moment. These differences of readings in simultaneous observations are called in meteorological language barometrical gradients. The lines on the surface of the globe connecting places that present the same barometrical pressure at any moment are called isobarometric.

On page 531, Yearbook of the Department of Agriculture for 1898, Prof. F. H. Bigelow puts the matter thus:

By the laws of vortex motion the winds approach the center in spirals, the circular and centrifugal movements increasing every moment. At the core within the walls of the columnar vortex the air circulates about the calm central part, gradually rising to the cloud stratum, just above the inflowing disk. Here the air flows out suddenly on all sides, the circular motion decreasing, the air cooling by expansion, causing a great, thin sheet of rain 200 to 300 miles from the center. At this distance the vortex sheet turns up suddenly (not down, as usually stated) and discharges the expended matter into the high upper currents of the atmosphere. The feeding wind lines are more nearly parallel to the ground than the upper discharge lines, but they all form a columnar vortex of unusual configuration. There is probably no feature of nature more interesting to study than a hurricane, though the feelings of the observer may sometimes be diverted by thoughts of personal safety.

(c) *Movements of the hurricane*.—Rotary storms have two distinct movements, and a failure to understand each of these and its peculiarities is responsible for much of the confusion so painfully apparent in public thought, whereas a clear comprehension of these two movements affords at once both a key to much valuable information on this subject and a basis upon which to rest many reliable prognostics, as well as precautionary measures for the protection of life and property. Anyone desiring to be informed on this point will do well to take pencil and paper and by a careful study of actual drawings will soon come to a clear understanding of the changes which necessarily result from a combination of a gyratory and a translatory motion of the winds at any particular place within the disturbed area during the passage of the storm.

(1) *Gyration*.—The first motion we will notice is that about the center of the storm. There is, at the very center of the storm, a region of calm, sometimes called the “eye of the storm,” which averages about one-thirtieth of the diameter of the entire hurricane. The motion about this central region is, in the northern hemisphere, invariably from the right to the left; that is, we have east winds on the north, west winds on the south, south winds on the east, etc. The path of a particle of air is very nearly circular when it is close to the center but departs more and more from the circle as its distance from the center increases. This is because the winds approach the center in spirals, one of the results of which is an increase in the angular motions as the center is approached as well as an increase in the velocity and violence of the winds. It is this circular motion that renders the central area of the hurricane so dreadfully destructive, for which reason this motion should be carefully studied as many of the precautionary measures must be based upon its peculiarities. Then, again, as the inflowing winds ascend about the central area they become still more nearly circular at certain elevations and at still greater heights become more or less divergent and finally become completely so, flowing outward in radial lines, as shown by the cirrus plumes; but the outflow is often not perceptible except in the direction toward which the whole whirl is moving. These features of the gyratory motion at different elevations afford a basis for the most reliable premonitions of the formation and progress of the hurricane, as will hereafter appear.

(2) *Progression*.—In addition to the circular vortex motion just discussed the hurricane has a translatory movement; the center describes a path resembling a parabola whose opening between the branches is directed toward the east. The rate at which the center moves along this path varies not only in different hurricanes but even in the same hurricane at the different stages of its progress. The path of the hurricane may be considered as made up of three divisions, viz, the

first branch, the recurve, and the second branch. It is highly probable that while the hurricane is passing along the first branch the rate of movement is slightly on the increase, while in the vicinity of the recurve the rate is retarded, especially at the recurve of narrow parabolas where the vortex may remain practically stationary for a time.

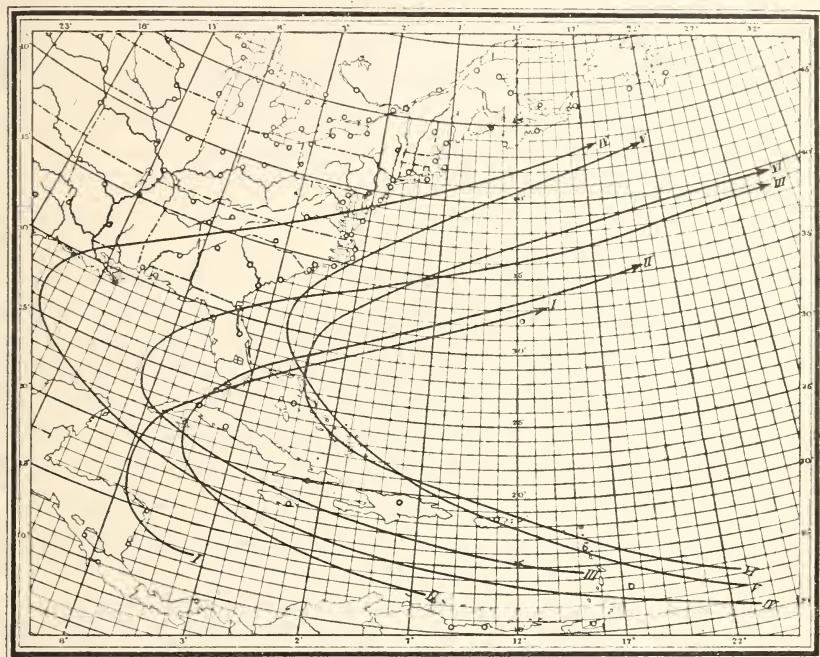


FIG. 3.

In the second branch of the track this translatory motion increases steadily and may attain 30 or 40 miles per hour. Perhaps 18 miles per hour would be a fair average for the hurricane along the first branch of its path. This path changes in form, being more or less open, at the different periods of the hurricane season, as may be readily seen from an inspection of fig. 3. The paths of hurricanes shown on this chart represent respectively the averages of certain typical groups of paths. It is not to be supposed that hurricanes only occur along these paths; on the contrary, they may occur anywhere within this hurricane region, but when they do occur, they are likely to run in paths parallel to the types here shown for the different seasons. This chart is an effort to present graphically Father Viñes's "Law of the normal direction of the tracks at the different dates and latitudes," which law as originally tabulated is also reproduced in Table I. The form of the track for the different months and decades specified remains the same, but its geographical position depends upon the

place of origin or the point at which the hurricane enters the region of the West Indies. In other words, should a hurricane form or enter the West Indian waters at the points arbitrarily assumed on the diagram above referred to, then it would most likely follow the track laid down. These laws are of value, therefore, only after the latitude and longitude of the vortex of the hurricane have been ascertained at any particular time, as it is then possible to locate the probable path of the entire storm if the proper decade or month is taken into account. It is plainly evident that the path of the hurricane soon carries the hurricane beyond the tropics into the temperate zone where it assumes more and more the characteristics of a cyclone by spreading out over a larger area and thus losing its violent nature as it journeys northeastward; hence it may be said that the hurricane bears within itself the seeds of its own destruction.

Referring to figure 3, it will be seen that Track I is intended to represent the average path of a hurricane occurring during the first decade of June or the third decade of October; Track II, a hurricane occurring during the second decade of June or October; Track III, a hurricane occurring during the third decade of June or the first decade of October; Track IV, a hurricane occurring in July; Track V, a hurricane occurring in August, and Track VI, a hurricane occurring in September.

TABLE I.—*Normal directions of the tracks at different dates in different latitudes, as given by Viñes.*

Dates.	Directions.						
	W.		WNW.		NW.		NNW.
	°	°	°	°	°	°	°
August	10	15	15-20	20-25	25-27	.....	28
July and September.....	10	15	15-24	.....	25	.....	26
June 21-30 and October 1-10.....	10	15	15-20	.....	21	.....	22
June 11-20 and October 11-20.....	10	.....	12-14	.....	15-16	17	18-19
June 1-10 and October 21-31.....	10	12	13	.....	13-14	.....	15

Dates.	Directions.						
	N.		NNE.		NE.		ENE.
	°	°	°	°	°	°	°
August	29-33	.....	34	.....	35-40	.....	.....
July and September.....	27-29	.....	30	.....	32	33-35	35-40
June 21-30 and October 1-10.....	23-26	.....	27	28	29	30	31-40
June 11-20 and October 11-20.....	20-23	.....	24	25	26-30	.....	.....
June 1-10 and October 21-31.....	16-20	.....	22	23	24-30	.....	.....

For a full discussion of this law see "Cyclonic circulation and the translatory movement of West Indian hurricanes," page 19, et seq.

CHAPTER II.

PREMONITORY SIGNS OF THE EXISTENCE AND MOVEMENT OF A HURRICANE.

Nature mercifully forewarns the careful observer of the approach of dangerous atmospheric conditions and disturbances by signs more or less definite and reliable. When taken in combination, especially over large areas, these signs are unmistakable, and are more evident at the very places over which the storm's center is about to pass. These signs afford no basis for "long-range forecasts;" we can not by them foretell the formation of these storms weeks and months in advance. About all we can hope to do is to ascertain the existence of the disturbance at a distance and predict its probable path.

Bearing in mind, then, the physical structure of the hurricane, as above set forth, we are prepared for an intelligent consideration of attendant phenomena, some of which must always be present, and are well-recognized premonitions of the existence and movement of the West Indian hurricane. It is not to be understood that a hurricane follows upon the appearance of each of the signs mentioned below, nor is a hurricane necessarily heralded by all the indications given, but the appearance of one or more of these signs during the hurricane season should inspire alertness on the part of the observer in proportion as they accumulate and become more and more unmistakable as the danger draws nigh. These signs are such as the observer recognizes by means of the barometer, the sea, the air currents, the sky, the atmosphere, and the surface winds. The nature and significance of these warnings are easily understood from the definite lines upon which the hurricane is formed.

1. *The barometer.*—This instrument, if a good one, and more especially the self-recording barometer or barograph, is a most trustworthy friend during the hurricane season: in fact it is indispensable in the study of the hurricane if one desires to possess all possible foreknowledge. It often gives the observer the first indication of distant cyclonic formation; it keeps him reliably posted as to the tempest's progress, and brings the first ray of hope that the worst is over. The first intimation to be looked for, and to be detected only by means of the barometer, is an increase in the atmospheric pressure, as shown by an abnormal

rise of the barometer. This increase may be due to the flow of air toward the distant low pressure or it may mark the pericyclonic ring of high pressure about the vortex; it is often the earliest possible tidings of the hurricane. This rise usually occurs when the storm center is far distant—possibly as much as 500 miles—from the observer. It is followed by a fluctuating barometer, due to irregular and conflicting air currents. After this the barometer begins a gradual decline, the fall becoming more rapid as the storm approaches. The passing of the center is promptly shown by a rising barometer, the rise being sometimes as rapid as the fall during the approach of the storm.

2. *The sea.*—The sea may also be relied upon to give very early tidings of the existence of a cyclonic formation, by the appearance of long rolling swells, apparently without cause, which are rapidly propagated from the storm's center in all directions. These are sure signs of the existence, but not necessarily of the approach, of a storm; the storm may be approaching or passing, the swells are the same. The sea often has a glassy appearance some days in advance of the storm, and is very clear. Then again it has "the appearance of a boiling pot, the waves running in all directions, with their caps falling back just as though a change of wind was coming." These waves and swells and rollers are greatly modified by islands and shoal water, so that each locality must be studied especially. The sea becomes more violently agitated as the hurricane comes on, and at its worst is truly awful.

3. *The air currents, or cloud movement.*—The air currents, as shown by cloud movement, especially the upper currents, afford valuable data for locating the disturbance and for determining something of the hurricane's probable path. As the currents at the cirrus level are believed to flow outward from the vortex in radial lines, a study of the cirrus clouds becomes at once highly important. But cirrus clouds are not all alike, nor do they all have the same significance. Hence it becomes necessary to classify, and in this, as in many other instances, we can at present do no better than to follow Dr. Viñes. He selects two extreme types: The first or typical cirrus is a snow-white, feather-like cloud, and on account of its fibrous structure is often called "mare's tails." The stem or shaft of the "feather" is very dense fibrous. If there be two or more of these cirrus plumes all of them converge to a point on the horizon, thus locating the center of the disturbance. The second type is of a filiform structure, belt shape, and of great extension. These clouds may form belts or zones across the sky and resemble more or less the tail of a comet, so attenuated or gauze-like are they in structure. The first type of cirrus belongs to a hurricane of great violence though of small diameter. It usually appears when the storm is between 300 and 400 miles distant

from the observer. The second type pertains to hurricanes of large diameter but of moderate violence, and usually appears when the storm is yet distant 700 or 800 miles.

Between these two types there is an almost endless variety of cirrus forms, but the character of the approaching storm may be fairly estimated by the nature of the precursory cirri, remembering that the more nearly they conform to the first type the more perfect the cyclonic formation; and the greater the departure from the first and the more like the second, the less perfect though more extensive the cyclonic formation.

These highest cirrus bands or plumes therefore tell at once the direction in which the storm center is likely to move, and the observer who finds them streaming toward or over himself may know that the center is coming toward him.

On the other hand, the lower clouds and winds tell us only the location of the center at any moment, and we must observe these for several hours in order to determine how they are changing before we can conclude anything as to the movement of the center.

The lower air currents, as shown by the movement of the lowest cumulus clouds, circulate so nearly in a circle that the storm center may be assumed to be in a direction at right angles to the cloud motion. Above these cumuli the currents make angles with the bearing of the vortex that are sharper as the cloud level is higher. Fig. 4 presents these relations as they are believed to exist in a well-developed hurricane of considerable intensity. The center of the storm is shown in the lower right-hand corner of that figure; the air currents around that center generally show some such arrangement as indicated by the arrows; the highest cirrus clouds move directly outward from the center on all sides, but by far most decidedly in one direction, namely, that toward which the storm is moving, as, for example, west-north-west in the diagram; the cirro-cumulus clouds move in paths that make an angle of about $22\frac{1}{2}^{\circ}$, or two points of the mariner's compass, with the radius drawn to the vortex of the hurricane; the motion of the cirro-stratus clouds makes a still greater angle, say 45° ; that of the alto-cumulus clouds makes an angle of about $67\frac{1}{2}^{\circ}$, or six points, and that of the lower cumulus clouds an angle of 90° , or eight points, while the surface winds make a still greater angle, and therefore flow inward. All hurricanes are not perfect in their organization, consequently the observer must be prepared for and expect modifications in the above relations. The radial movement of the cirrus clouds is so frequently to be relied on that preference should be given to these clouds in determining the location or bearing of the storm center and its probable progress, especially while it is yet far distant.

If there be no cirrus clouds then quite possibly the storm is not advancing toward the observer, but will pass by him to the right or

the left. In this case its movement may be determined by studying the motion of any lower cloud that is visible, or if need be, that of the wind. To this end the observer must carefully determine the direction of motion of wind or cloud, from time to time, several hours apart. If this motion veers, namely, changes in the order N., NE., E., SE., S., SW., W., NW., N., then the storm center as it advances will deviate to the right of the observer's station. If the wind backs, namely, changes in the order N., NW., W., SW., S., SE., E., NE., N., then the center will deviate to the left of the station. If no veering or backing is observed, then the storm center must be moving very nearly toward the observer.

The exact direction of movement of the cloud or wind is best observed by the help of a nephoscope, which is essentially a horizontal mirror upon which one may lay a short piece of stick or wire and adjust this until it exactly covers the reflection of any cloud that is seen moving across the mirror.

(NOTE.—The latest confirmation of the general rule that high cirrus clouds flow from the hurricane center outward, but principally in that direction toward which the center is moving, comes from Mr. John T. Quin, editor of the *St. Croix Avis*, published at Christianstad, in the island of St. Croix. In that journal for September 14, 1901, speaking of the hurricane of Wednesday, September 11, he says: "It may interest amateur observers to mention that the first hint of the recent storm was given by the sky. A careful observation of some high clouds at 5 p. m. on Tuesday, September 10, showed that they were coming from east-southeast. The editor mentioned this fact and its probable significance to a friend at that time, and the Weather Bureau's telegram arrived a couple of hours afterwards. Yesterday, the 13th, the storm having passed us, the high clouds were observed moving from about west-northwest—that is to say, they were still coming from the cyclone center."—C. A.)

In fig. 4 we have shown in a general way the incurving of the wind and clouds near the center of the West Indian hurricane, but for the convenience of those who prefer a more direct statement we give the following table, showing in the first column the bearing of the hurricane center from the observer; in the second column the approximate direction of movement of the lower clouds, viz, either the cumulus or the scud; in the third column the direction of the wind when the location is quite free from obstacles that may change the direction. At various distances from the center these wind directions vary somewhat, so that those given in this column are not those invariably experienced, but a range of two points must be looked for. Thus, if the center is east of the observer he may confidently expect the lower clouds to be moving very nearly from the north, but the lowest surface winds may be anywhere between north-northeast and west-north-

west. This consideration shows the importance of observing the cloud directions with great care. In order to do this with considerable ease the landsman has only to make use of a small mirror or a bowl of water in which he can see the reflection of the clouds. He is to hold the eye steadily in one position while the reflection of the cloud is seen to pass across the mirror or water. Lay a straight edge across representing the path of the clouds, and then determine the angle which the straight line makes with the meridian. One ought really to have a very correct idea of the true north and south line, and if a magnetic compass is used one should make allowance for its deviation from the true north, although fortunately this is quite small in Porto Rico.

General relations of winds to the storm center.

The storm center bears—	The low clouds move from—	The winds blow from—
ESE.	NNE.	N.
E.	N.	NNW.
ENE.	NNW.	NW.
NE.	NW.	WNW.
NNE.	WNW.	W.
N.	W.	WSW.
NNW.	WSW.	SW.
NW.	SW.	SSW.
WNW.	SSW.	S.
W.	S.	SSE.
WSW.	SSE.	SE.
SW.	SE.	ESE.
SSW.	ESE.	E.
S.	E.	ENE.
SSE.	ENE.	NE.
SE.	NE.	NNE.
ESE.	NNE.	N.

4. *The sky.*—The passage of the pericyclonic ring surrounding a hurricane is marked by deep blue and nearly cloudless skies, followed by a few days of sudden and decided changes in the appearance of the sky; quick changes from clear to cloudy and from cloudy to clear; small fragmentary clouds may often be seen passing across the sun's disc; at sunset the sun appears to be shorn of his beams and shines with a pale sickly light, and the sunrise and sunset colors are unusually brilliant. Solar and lunar halos are frequently to be seen.

5. *The atmosphere.*—The atmosphere some days in advance of the storm possesses comparatively low relative humidity and dew-point, then follows a period of great fluctuations in the humidity and dew-point. At times the air becomes very warm and sultry, as if from a furnace, often presenting a hazy or milky appearance.

6. *The surface winds.*—Some days preceding the storm the trade winds become unsteady, the light breezes dying away and then reviving again. Finally, if the rise in the barometer has occurred because of the passage of the pericyclonic ring, then the air settles down to a calm that is followed by a gradually increasing wind which blows in

gusts at first with occasional calms. "In the air there may be often heard queer sounds like the cracking of whips or far-away pistol shots. Besides this a deep rumbling noise—a sort of growling—may be heard."

7. *The weather*.—Fine and rather cool weather may be looked for during the prevalence of increased air pressure, but as soon as the barometer begins its steady fall, the sky begins to assume an angry, threatening aspect, and ere long has a peculiar indescribable appearance, which assures the observer of an approaching danger. This "something" about the weather must be experienced to be understood, but once seen it is readily recognized; it appeals directly to the senses, and may be that which impels the sea birds to make for the land, as if by instinct, to protect themselves from the fury of the coming gale.

In this connection we quote what a few eminent writers have said relative to premonitory signs of the approaching hurricane, and thus make this discussion as complete as possible. First we offer a few words from Professor Bigelow:

The physical features of hurricanes are well understood. The approach of a hurricane is usually indicated by a long swell on the ocean, propagated to great distances and forewarning the observer by two or three days. A faint rise in the barometer occurs before the gradual fall, which becomes very pronounced at the center. Fine wisps of cirrus clouds are first seen, which surround the center to a distance of 200 miles. The air is calm and sultry, but this is gradually supplanted by a gentle breeze, and later the wind increases to a gale, the clouds become matted, the sea rough, the rain falls, and the winds are gusty and dangerous as the vortex comes on. Here is the indescribable tempest, dealing destruction, impressing the imagination with its wild exhibition of the forces of nature, the flashes of lightning, the torrents of rain, the cool air, all the elements in an uproar, which indicate the close approach of the center. In the midst of this turmoil there is a sudden pause, the winds almost cease, the sky clears, the waves, however, rage in great turbulence. This is the eye of the storm, the core of the vortex, and it is perhaps 20 miles in diameter, or one-thirtieth of the whole hurricane. The respite is brief and is soon followed by the abrupt renewal of the violent wind and rain, but now coming from the opposite direction, and the storm passes off with the several features following each other in the reverse order.—Yearbook, Department of Agriculture, 1898, page 531.

We now quote Mr. Francis Watts, F. I. C., F. C. S., who puts the matter thus:

Much is heard about the prediction of hurricanes. It should be clearly understood what is meant by such an expression. The prediction of a hurricane weeks or months before its formation is clearly a thing impossible in the present state of our knowledge. All that can be done is to ascertain the existence and predict the probable course of a cyclone already existing. We have seen that a cyclone is built on certain definite lines and certain phenomena invariably attend its approach.

The following premonitory indications are largely taken from the United States Pilot Chart for August, 1891. Before a hurricane the barometer is somewhat higher than usual, with cool, very clear, pleasant weather; there is a low long swell from the direction of the distant storm; the sky is covered with a quantity of light feathery cirrus clouds (Mare's tails), radiating from a point on the horizon, where a whitish arc indicates the bearing of the center. If the cirrus plumes are faint and opalescent in tint,

fading gradually behind a slowly thickening haze or veil, the approaching storm is an old one of large area; if they are snowy white, projected against a clear blue sky, it is a young cyclone of small area, but great intensity. Great activity of movement of the upper clouds while the storm is still distant indicates that the hurricane is of great violence.

As the storm approaches, the following unmistakable signs display themselves: The barometer falls rapidly; halos are seen about the sun and moon; the ocean swell increases, the weather becomes hot, moist, and oppressive with light variable winds; deep red and violet tints appear at dawn and sunset, which tints assume a coppery glare of ominous aspect; a heavy mountainous cloud bank on the distant horizon indicates the position of the approaching storm; the barometer falls more rapidly, and finally, if the observations are made on or near the storm track in the West Indies, the wind begins to blow in a direction between the northeast and northwest soon rising to hurricane force, increasing till the central calm passes over with violence from the south to southeast.—Occasional Bulletin, No. 10, Botanic Station, Barbados, p. 7.

The following extracts from a memoir by Dr. Enrique del Monte of Havana, are reprinted from Bulletin H, West Indian Hurricanes, by Prof. E. B. Garriott, pages 13-18:

First phase of the hurricane: The anticyclone.—Hence, we have already the first phase of the hurricane; and when its vortex is on an average 1,500 miles off. This phase is called the anticyclone. As its name indicates, it is the reverse of the cyclone. In fact, the meteorological elements follow in it a course different from the normal, and quite different, too, from that in the dominion of the hurricane.

Its distinctive features are the following:

1. An anomalous rise in the barometer. It reaches sometimes an exaggerated maximum.
2. Fine and rather cold weather. The temperature goes, on an average, 14° F. below the normal.
3. Cloudless sky, and of a decidedly indigo blue. Consequently in this kind of weather the dew-point and relative humidity are always far below the normal.
4. Persistency of the anticyclonic winds. That is to say, the daily shiftings from the land to the sea breezes, and vice versa, disappear entirely, or at least are greatly disturbed.
5. Different order in the circumgyration of the atmospheric currents from those in the hurricane. In the anticyclone the gradation is from right to left, beginning from the lowest current.

Summing up we will say, that all the anticyclones that may appear to the observer, presenting the features above referred to, always indicate a priori the existence of an atmospheric disturbance. In the island of Cuba, when they appear in the months of cyclonic activity, they must be always carefully observed and studied, as their subsequent positions may furnish the observer with valuable information regarding the hurricane. On the other hand, when their appearance takes place in the months of no cyclonic activity, they pertain to hurricanes of high latitudes, although in some instances, as we shall see in the next section, they may offer some danger to navigation on the northern Cuban coasts.

Second phase of the hurricane—Mean zones or intermediate spaces between the anticyclone and the cyclone.—Soon after the influence of the anticyclone has passed by, and while on the other hand the approaching hurricane is still far enough away to prevent its detection, the following phenomena are generally noticed:

1. The barometer begins to fall slowly. Irregularities and fluctuations in its column are always noticed, owing to the antagonizing influences exerted on it.

2. The appearance of the sky is highly changeable, passing sometimes in a few minutes from entirely clear to cloudy and vice versa.

3. Consequently the temperature and moisture of the air are also very fluctuating.

4. The wind directions in the different atmospheric strata are singularly unstable. We have frequently observed the passing of those currents, in a very short time, from anticyclonic to cyclonic and vice versa.

All the above weather features are always more or less perceptible under approaching cyclonic conditions and after the gradual recession of the anticyclone. The brightness of this phase obviously depends on the power exerted by both the anticyclonic and cyclonic systems as well as on their relative position to the observer.

Third phase of the hurricane—Changes and phenomena to be observed in the upper strata of air.—This phase begins when the anticyclone in its progressive motion is so far away as to be imperceptible to the observer, while the hurricane is gradually approaching him.

Alteration of the light in the upper strata of air—Reddish and ruby skies.—This phenomenon is always noticeable when the outermost part of the hurricane begins to invade the place of observation. The unsettled weather, described in the last section, gradually disappears and the barometer falls now steadily but rather slowly. By this time the transparency and blueness of the sky, characteristic of the past anticyclonic weather, is succeeded by an opaqueness or veil called cirrhose veil, so extremely subtle in the beginning as to render it almost imperceptible. Notwithstanding its subtlety this veil exerts a very great absorptive power on the solar rays, its principal feature being the almost entire absorption of all the prismatic colors, except red. The dispersive and absorptive powers are singularly remarkable when the solar rays are compelled to pass through a great portion of the atmosphere. Consequent upon this the sun's rising and setting are attended by an anomalous reddish coloration in the sky ending or beginning when the sun's altitude is, on an average, 15° ; the coloration increases as the altitude decreases.

Precursory cirri and their magnificence—Invaluable data to be derived from their appearance.—Just here the observer is confronted with the most splendid phenomenon to be observed in tropical meteorology.

Soon after the reddish coloration is noticed the tribe of cirri makes its appearance. These clouds are oftentimes called "Pele's Hair," "Mare's Tails," etc., on account of their fibrous or filiform structure. As is well known, they resemble in their form a feather or plume of highly variable dimensions.

The appearance of these clouds whenever pertaining to tropical hurricanes, shows an organization seldom noticed, if not unknown, in those attending high-latitude storms. In fact, during a long stay in New York, N. Y., we have had ample opportunity to watch a good many specimens of cirri in connection with storms of very different energies, but have utterly failed in detecting any similitude with those frequently observed in the West India hurricanes.

The shape of the typical tropical cirrus is that of a most perfect and remarkably beautiful feather or plume, snow white, in which the shaft or stem is of a fibrous structure, great density, and averaging 80° in angular length. The barbs or vanes are equal and closely distributed on both sides of the stem, being of filiform structure, divergent, and of marked outward curvature.

It is also noticeable in connection with these clouds that when there are two or more, as is usually the case, all of them agree in their directions, converging to a given point on the horizon. This point is called the focus; i. e., the perspective vanishing point.

Whenever these cirri are carefully observed a great activity or instability is always detected as taking place in their masses; their lengths are frequently seen increasing or diminishing in a short space of time.

In spite of this instability the cirrus is never deflected from its primitive direction.

Solar and lunar halos, parhelia and paraselene, threatening skies.—Shortly after the appearance of the precursory cirri it is always noticeable that the subtle opaqueness or veil has gradually acquired density and now resembles a light curtain of a milky appearance. During this phase the delicate filaments of the cirri are almost imperceptible, owing to the interposition of the veil.

Solar and lunar halos are phenomena always attending this kind of weather. The parhelia and paraselene are seldom noticed. At the beginning the halos are of a weak appearance, but later, and when the veil is still denser, they usually display extraordinary brilliancy, which afterwards gradually declines as the veil is changing to a dark cinereous color.

The reddish colorations attending the sun's rising and setting are now of a most indescribable and threatening appearance, resembling the resplendence of a bright polar aurora. The ruby color gradually turns into crimson as the sun approaches the horizon, and shortly after sunset the whole sky has the appearance of an enormous conflagration.

Cirrhose arch—Its appearance.—While the cirrhose veil is increasing in density, as we have seen in the last section, it is always noticeable that at a given point in the horizon the condensation of the veil is greater. There the veil has the appearance of a segment of a circle at first tangent to the horizon, but gradually rising to a maximum of perhaps 10° above. This arch is generally called the cirrhose arch. Its color at the beginning—that is to say, during the phase of which we are now speaking—is the same as that of the veil covering the whole hemisphere, only that the accumulation of vapors being greater where the arch appears, its reflecting power is necessarily greater; so that in spite of the identity of colors between the cirrhose veil and the arch the latter seems perfectly detached, a similar phenomenon to that always noticed in the tail of a comet, where the tail is brighter near the borders than along the middle, in spite of the uniformity in its color.

The point in the horizon at which this arch is formed always coincides with the vanishing point of the observed cirri, and therefore with the bearing of the vortex from the observer. In fact, the arch is but the visible upper part of the approaching hurricane.

Seamen navigating the tropical seas in the hurricane season must carefully observe whether, after the appearance of the precursory cirri, the cirrhose arch is formed, attended by halos and reddish colorations, with falling barometer. In this case there is no time to be lost. Let them consult without delay the charts of normal tracks for the different months of cyclonic activity, and if they find themselves to be in a dangerous zone adopt immediately the measures they may deem necessary.

Bar of the hurricane; its appearance—Data to be derived from its observation.—The cirrhose arch, described, gradually changes as the hurricane is approaching. At the beginning its color is of a whitish-milky appearance, but now its color is rather dark and opaque, soon to be turned into black. After this change in its appearance the arch is called the bar of the hurricane.

The bar has the appearance of an arch whose altitude above the horizon is generally from 10° to 15° . It is formed in its upper section by cumulo-stratus, and in the lower one by a nimbus of great size and black color. The base of the bar is always concealed below the horizon, so that a want of continuity between the bar and the horizon is never detected.

Showers and squalls; their phenomena.—Shortly after the bar is formed in the horizon the nimbus of the hurricane begins to overrun the skies with inexhaustible succession and high speed. Showers of short duration begin, and the wind velocity increases from that moment. The barometer that has been slowly falling since the beginning of the second phase now drops abruptly.

It may be well to notice here that in every perfect hurricane of great or relative moderate intensity the rain at the beginning is of a showery nature, attended by

squalls from 55 to 65 miles an hour, while the mean velocity of the wind is from 35 to 40 miles. On the contrary, as the vortex approaches the rain is always continuous, although highly irregular, the showers succeeding each other at shorter intervals and always attended by furious gusts that apparently attain 100, 110, and sometimes 120 miles an hour.

As is well known, the energy of every tropical hurricane is always in close relation with the frequency and fury of the attending showers. The hurricanes are fed and their activity maintained unabated by the characteristic showers which accompany them, by reason of the fact that the rapid upward convection contributes largely to a more and more severe precipitation.

Of all the premonitory signs of an approaching hurricane, the following, at least, may be regarded, so far as the West Indies are concerned, as invariable, not to say essential: First, a continuous fall of the barometer; second, a strong wind from some northerly point (northeast, north, or northwest), blowing with an increasing force; and third, a rough, intumescent sea. These are practically invariable, and if one or more be wanting there is little cause for alarm.

While searching through an old work entitled *Atlas Geographus*, published in London in 1717, the following interesting reference to hurricanes was found in Volume V, page 520, and is here reproduced in conclusion of this chapter:

It (St. Kitts) was formerly much troubled with earthquakes, which are in a great measure ceased since the eruption of a sulphurous mountain in the island; but hurricanes are still frequent here, and the European inhabitants used to send about June to the natives of Dominica and St. Vincent, who constantly gave them notice of the hurricane about 10 or 12 days before it came. In Lowther's *Philosophical Transactions*, Vol. II, page 105, the curious will find certain prognosticks of the approach of a hurricane, as they were discovered by an Indian to Capt. Langford. They come generally in August, on the full change or quarter of the moon, and never before the 25th of July, nor after the 8th of September. Among other signs of their approach, the skies are very turbulent, the sun redder than usual, and the hills clear of clouds or fogs. In the hollows of the earth or wells there is a great noise; the stars at night look very big, with burs about them, the northwest sky very black, and the sea smells stronger than usual. Sometimes on the day when it comes the wind blows very hard west out of its usual course.

CHAPTER III.

THE APPROACH AND PASSAGE OF A WEST INDIAN HURRICANE—SUGGESTIONS RELATIVE TO PREPARATIONS FOR SUCH STORMS.

During the hurricane season due diligence should be exercised by keeping a close watch on the state of the weather in order that the first signs or indications of the formation or approach of a hurricane may be detected. So soon, then, as the existence of the hurricane is manifest the next serious consideration is the determination, so far as practicable, of the observer's position with reference to the center and bearing of the storm, because this will afford a basis for subsequent action. The safest conclusion on this point will be reached from a careful study of weather telegrams from surrounding points; but in the absence of these we must study cloud movement and the surface winds, in connection with the law governing the paths described by the centers of hurricanes at the different seasons and latitudes, as explained in a preceding chapter. This law should be kept in mind, as the suggestions here made are subject thereto. In this connection it is also advisable to study Fig. 3 and review what is said in the preceding chapter relative to the relation between the bearing of the vortex and the cloud movement.

If high cirrus clouds are present and visible they will indicate the bearing of the center from the observer; if there are no cirrus clouds, or if the sky is overcast by lower clouds, it is then best, perhaps, to study the low cumuli, as these move very nearly at right angles to the bearing of the vortex. Hence, if the observer stands facing in the direction from which the low cumulus clouds are coming, then turns to his right through an angle of 90° , he will be looking in the direction of the center. If, however, only the surface wind is observable, then he must turn to his right through an angle greater than a right angle, since the surface winds make with the direction of the storm center an obtuse angle, especially at some distance from the center. A single observation of the wind does not tell anything with regard to the path of progress of the storm. Having now ascertained as best we can the location of the storm center, the observer next considers whether the center will pass over him to the north or to the south. Knowing this, then, the directions from which the wind will blow during the

approach and passage of the storm will become known and precautionary measures may be taken accordingly. Unfortunately, the best that can be done in the solution of this problem is only an approximation. In fig. 4 five cases of such hurricane paths as can occur in the West Indies are indicated. The position of the observer may be at either of the figs. 1, 2, 3, 4 or 5—i. e., west or north of the central calm region. If the storm center is coming directly toward him he will

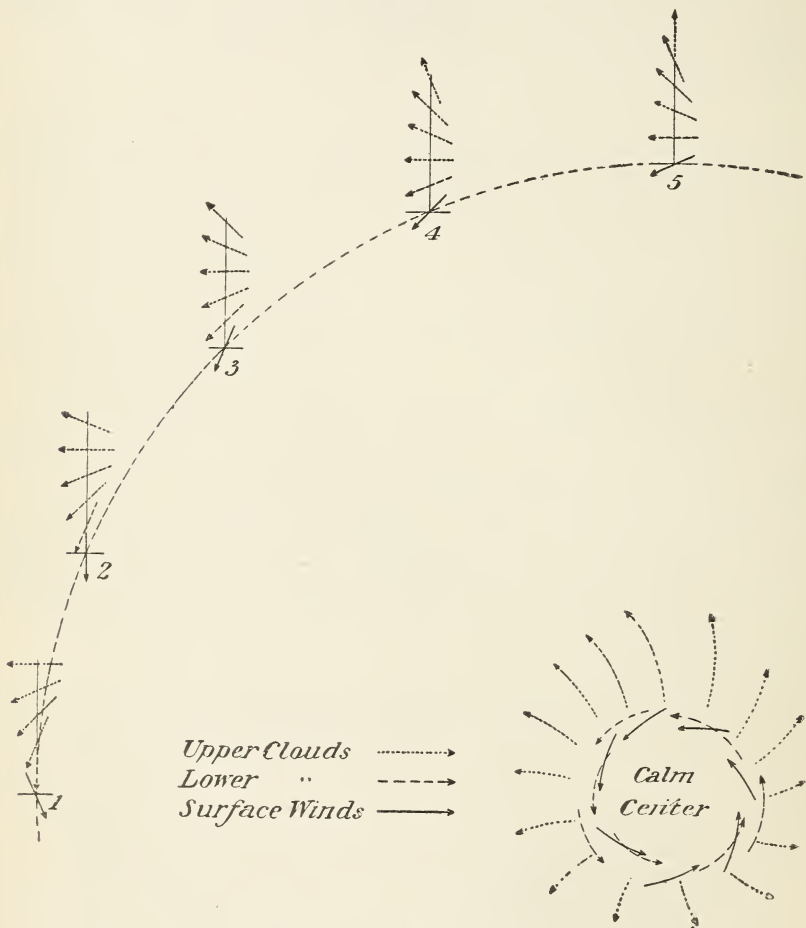


FIG. 4.

know this by the direction of motion of the clouds in the sky above him. The motions of the clouds are shown by small arrows.

The observer located at the points 1, 2, 3, 4, 5, in fig. 4, and having a storm approaching him from the calm center C, will usually observe that the successive layers of clouds above him are moving in different directions, as indicated for each location in the following table, and

also shown by the arrows placed vertically above each location in fig. 4. The kinds of clouds and their respective movements vary quite regularly as we ascend above each locality.

Table showing movements of successive layers of clouds.

stratum of cloud or mist.	Inclination of movement to radius.	Direction of movement of winds and clouds (true, not magnetic) as observed at different stations.				
		1.	2.	3.	4.	5.
(1a) Snow-white cirrus, feathery plume, fibrous mares' tails, flowing from the center, or converging to the center, appearing when the center of a small storm is 300 miles distant.....	0.0	E.	ESE.	SE.	SSE.	S.
(1b) Cirrus of filiform structure, long belts or zones, gauzy structure like comets' tails, appearing when the center of large storm is 700 miles distant.....	0.0	E.	ESE.	SE.	SSE.	S.
(2) Cirro-cumuli.....	22.5	ENE.	E.	ESE.	SE.	SSE.
(3) Cumulo-stratus, or dense cirrus veil.....	45.0	NE.	ENE.	E.	ESE.	SE.
(4) Alto-cumulus.....	67.5	NNE.	NE.	ENE.	E.	ESE.
(5) Cumulus.....	90.0	N.	NNE.	NE.	ENE.	E.
(6) Wind.....	112.5	NNW.	N.	NNE.	NE.	ENE.

Case 1: It most frequently happens in the Windward and Leeward islands that the center of the storm (C) moves nearly westward toward the observer at O_1 and in the direction of the higher cirrus clouds, as shown by the large arrow over the observer. The relations of the air currents to the path of the storm, as previously explained, are shown by the small arrows at different altitudes above the observer. Under these conditions the northeast trade wind will back toward the north as the storm approaches. If it veers to the east the center will pass south of O_1 . If it remains steady or backs to the northwest the center will pass north of O_1 . The winds will constantly increase in intensity up to the hurricane at the time of the nearest approach of the center. If the latter pass over O_1 there will be an almost dead calm, lasting from fifteen to thirty minutes, depending upon the magnitude of the storm and the rate at which the center is moving. This calm will be followed by a sudden renewal of the wind from the opposite direction, and it will possibly blow with increased violence for a time, after which it will gradually abate.

Case 2: This case is about as frequent in the West Indies as case 1. The center of the storm is supposed to be at C and moving west-northwest, as shown by the large arrow for the cirrus cloud placed above the observer at O_2 .

In general, in all these cases the storm center is assumed to be moving toward some one of the five positions of the observer. If he, by watching the winds or clouds, finds that the center will pass toward the right, namely, north of him, or toward the left, viz, south of him, then this diagram will enable him to ascertain in that case the winds and the changes in the winds that may be expected at his station.

Perhaps, then, the most valuable lesson to be learned from a review of the above text and figures is this, viz: The more tenaciously the surface winds cling to the north the greater is the probability of the center's passing over the observer; a strong tendency in the surface wind to change toward the east is to be construed as a sign that the storm's center will pass to the south of the observer, while a westward inclination indicates the passage of the center to the north of the observer.

Having ascertained his position with reference to the bearing of the vortex and the path of the hurricane, the observer is now prepared to take intelligent action in the matter of precautionary measures, which will be discussed under two heads: First, supposing the observer to be stationed on the land, and second, on the sea.

1. *On land*.—It would seem scarcely necessary to suggest to persons living in the "hurricane belt" the advisability of making a careful inspection of their buildings at the beginning of the hurricane season for the purpose of ascertaining the conditions of the doors, windows, and fastenings, as well as to provide materials and tools required in such an emergency and have these in a convenient place.

If a hurricane is actually approaching, the first care should be to barricade the dwelling house, and in proceeding to do this it is well to begin by barring the side exposed to the wind already blowing. If the observer has reason to believe that the center will pass over him, then extra care should be exercised in securing the north and south sides of the building, as these will be subjected to the greatest strain. When the calm arrives the time should be occupied in re-examining the fastenings on the south side to see if any have been shaken loose, as the storm will be renewed with great violence from that direction. The windows on the north side may now be opened for the purposes of ventilation. If the wind is blowing from a point considerably to westward, and the observer has reason to believe that the center will pass north of him, then he should bar the north and west sides leaving the south and east until later, provided the house is to be occupied during the storm. If the indications are that the center will pass to the south, then the east and north sides should receive first attention, leaving the south and west sides until later, with the same proviso as above.

The dwelling house being now securely barred, whatever is to be done on the outside should then be done without delay. After all possible has been done for the protection of life and property, it only remains to select a place of retreat for personal safety. The strongest and best-protected room available, whether this room be in the dwelling or not, should be selected. It is highly important, however, that this room be of easy ingress and egress without having to pass through other rooms. Should the building be endangered by the violence of the storm,

and it is deemed advisable to leave it, perhaps a strong, well-built cellar, if such is available, would afford the best retreat, provided, however, the cellar is not liable to be flooded by the excessive rains which frequently accompany the hurricane. As the hurricane may occur at night it is advisable to keep a lamp burning—a good storm-proof lantern is best. To pass from one building to another in the darkness is extremely hazardous. The all-important thing under these trying circumstances is not to be found in any set of rules, but in a calm, deliberate judgment; a person who has lost self-control is totally unfit to be intrusted with the execution of precautionary measures.

2. *On the sea.*—The hurricane is without doubt one of the greatest perils of the sea. The following suggestions are offered, not that it is believed that any set of rules can take the place of good, experienced seamanship, but simply in hope of lessening the dangers by presenting suggestions that appear to be based upon sound principles. Effort is here made to point out the most dangerous and the least dangerous places and a possible method of escape, recognizing, however, that the entire management of the ship during the storm must be left to the skill of its master.

Each vessel should be provided with a barograph, or at least a barometer which should be kept in good order. During the hurricane season and when in the hurricane region, careful watch should be kept on the state of the weather; on the appearance of the slightest indication of a cyclonic formation, increased vigilance should be used, as the indications will increase in number if the storm really exists. Being satisfied that a storm does exist, it is highly important that the ship's position with reference to the bearing of the vortex be determined at once and as often thereafter as may be possible by the study of winds and clouds. Having ascertained whether he is on the right-hand or left-hand side of the path about to be described by the storm center, the navigator should study the modified form of a diagram given in Westerby's Handbook, and which is here presented as fig. 5.

For convenience, that side of the storm which is on the right hand of the storm track as one looks in the direction toward which the center of the storm is moving is called the right-hand semicircle, that on the left side the left-hand semicircle. The large arrow in fig. 5 indicates the direction and path of the storm's vortex. That portion somewhat forward and a little to the right of its center is conceded to be the most dangerous region and should therefore be carefully avoided. Supposing, now, that the captain of a vessel finds himself on the verge of a West Indian hurricane, say in the position (1) on fig. 5, and that he has sea room and a good manageable ship (of which he alone is judge), clearly he would be in very great danger should he remain in that position, as he would then experience all the fury of the gale. The proper course would seem to be to put his vessel before

the wind and run with it until the wind blows from the northwest quarter, and he may then lie to on the port tack to avoid being carried around the center, or he may follow the general rule and lie to on the starboard tack, which necessarily carries him away from the storm's center.

Next consider a ship in the position (2) which is the position of greatest danger. It is very difficult to say just what is the best course to

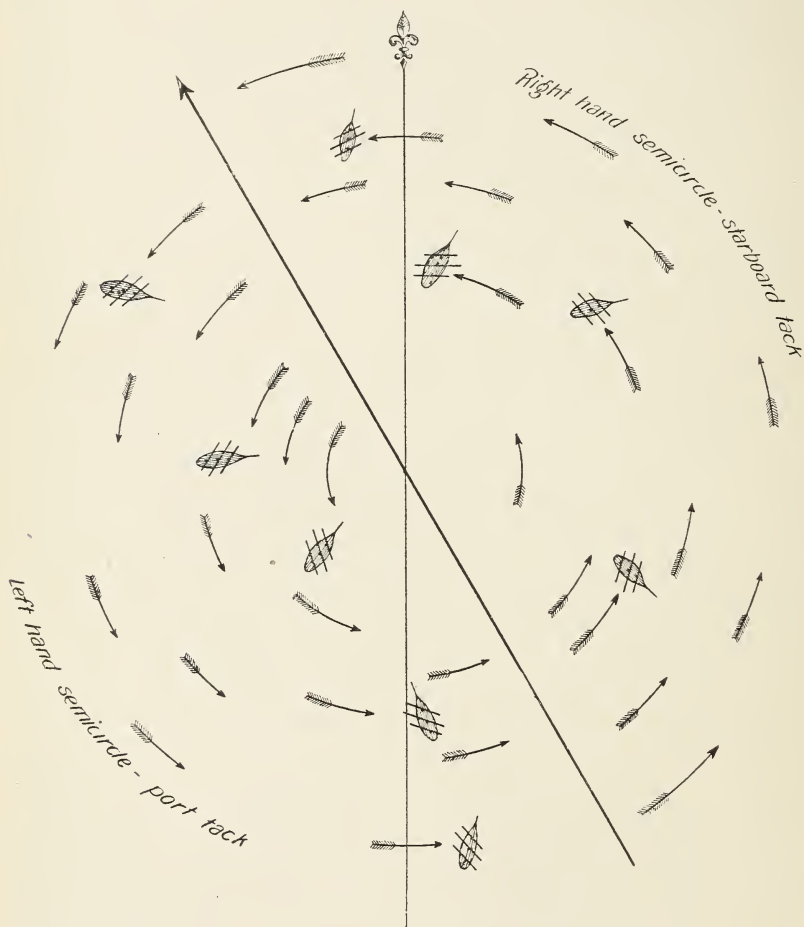


FIG. 5.

follow when in this position, but it would seem to be wise to make for the north or northeast with all possible speed, and should the wind be found coming from a more easterly direction this should be taken as a good omen and the course may then with safety be directed more to the northeast. If, however, the violence of the winds renders it necessary to lie to, this should be done on the starboard tack. By all means avoid running before the wind.

If in the position (3) fig. 5, the vessel might be allowed with perfect safety to run with the wind so long as she is permitted to keep a southeast or a south-southeast course, and then she may be allowed to lie to on either tack.

A vessel in the position (4) fig. 5, may lie to on the starboard tack or make as much northing as possible, and, if in the position (5) either make for the south or lie to on the port tack.

A quotation from Colonel Reid is appropriate in this connection. He says:

When a vessel is lying to, and the wind veers by the ship's head, she is in danger of getting sternway, even when no sail is set; and it is supposed that vessels have often foundered from this cause. When the wind veers aft, as it is called, or by the stern, this danger is avoided.

Again—

If it is desired to lay a ship to in a revolving storm, so that she will come up to the wind instead of falling off from it, the rule will be, when in the right-hand semicircle, to heave to upon the starboard tack, and when in the left-hand semicircle to heave to upon the port tack.

The following suggestion is taken from Davis's *Elementary Meteorology*, page 189:

A modern addition to the older rules for diminishing the danger of storms at sea is to spread oil on the waves, whereby their height is lessened and they break less frequently over the vessel. Even a small quantity of oil allowed to drip from a bag hung over the vessel to windward has been found by repeated experiments to be of great service. The oil greatly diminishes the combing of the waves.

CHAPTER IV.

BAROMETERS: THEIR CARE AND THEIR USE.

The barometer occupies such a prominent and important part in any discussion of the hurricane as not only to justify but even to demand a more extended notice of this instrument. It is not necessary, however, to enter into a detailed description of the mechanism of the various forms of barometer now in use. Modern ingenuity has brought this instrument up to its present state of remarkable perfection. The most common forms of the barometer are the mercurial and the aneroid. These only will be noticed in this connection.

1. The mercurial barometer is the only form of acknowledged scientific value, as it alone is capable of giving atmospheric pressures with the requisite precision. A very practical and satisfactory form of the mercurial barometer is that provided with the Fortin cistern. This pattern, as made by Green, of Brooklyn, N. Y., is in quite general use throughout the United States Weather Bureau Service. It consists of a glass tube about thirty-four inches long and one-fourth of an inch inside diameter, protected by a thin metal tube so made as to expose the top of the mercury column, and is provided with a scale of inches and tenths and vernier by which to read to hundredths of an inch. The cistern is an ingenious device for changing the level of the mercury in the cistern so as to adjust it to a fixed point, thus enabling one to detect at the top the smallest changes in the length of the whole column of mercury. This barometer should be set up in a place subject to slight changes in temperature, and should be placed and kept in a vertical position.

2. The next form to be noticed is that commonly known as the aneroid or holstetric barometer; the former term signifying "containing no liquid," and the latter "wholly of metal." This instrument for practical purposes is a really excellent one, and many arguments may be justly stated in its favor. A good aneroid from a responsible maker, if kept in order, will answer all ordinary purposes; that is to say, it will indicate, more or less accurately, the character and amount of barometric changes from day to day. Strange to say, it seems never to occur to some people that this delicate instrument could possibly

become deranged, and that it must be subjected to a careful inspection occasionally. As with a watch so with an aneroid—a really first-class instrument may become absolutely unserviceable through neglect. It is unreasonable to expect good service from such a delicate instrument under neglect or bad treatment. These barometers should be tested and possibly cleaned and oiled occasionally. The principal defects are the lack of perfect balance in the various parts, friction and looseness in the joints and bearings; all of which must be guarded against. High temperatures have a damaging effect upon the aneroid by weakening the composition metal of the vacuum chamber and the steel spring, so that what appears to be a rise in the air pressure may be due to the weakening of the spring on account of high temperature. This instrument should therefore be placed where it will not be subjected to great changes in temperature. On the face of an aneroid the word “compensated” is sometimes printed, meaning that the evil effects of temperature have been provided against in some way, but unfortunately the compensation is often very imperfect and can not be relied upon.

In this connection it is appropriate to give Professor Marvin’s “Test of the condition of aneroid.” He says:

Aneroids, seemingly good, are often defective, because some of the joints of the levers and pivots are too tight, causing the hand to stick and not move with the perfect freedom it should. The condition of an aneroid can be quickly tested in this respect by tapping the instrument on the side or bottom with the fingers or knuckles, or perhaps better by lifting the instrument about one-fourth of an inch from the table or cane-seated chair and replacing it somewhat sharply. Under this treatment, if the levers and joints are perfectly free, the hand will jump away from its position and return quickly with a vibratory and quivering movement, returning accurately to its original position. If the instrument is defective the hand in some cases will not respond to the slight knocks, or will do so without exhibiting any vibratory, quivering movement, or, especially upon being first disturbed, it will move some, but will not return to its original position.

Richard barograph.—A self-recording aneroid barometer has been devised by Richard, of Paris, and is now very widely used on vessels at sea as well as at stations on land. This instrument does not cost any more than a standard mercurial barometer and has the great advantage of enabling any one to see at a glance whether the pressure is rising or falling, and whether it has fallen so much as to indicate the presence of a hurricane. The barograph is a great additional safeguard against the sudden unheralded approach of a hurricane.

In order to appreciate fully the meaning of barometric changes one must find out the normal variations for any particular locality. The barometric gradients undergo very small changes within the Tropics. During the first half of the year the readings are a little above the yearly mean, and during the last half a little below the mean. In addition to these seasonal or annual variations there are

other and more important daily changes, which take place hour after hour about as shown in the following table, viz:

Table showing diurnal barometric changes at San Juan, P. R.

[Local standard seventy-fifth meridian time.]

Hour.	June.	July.	Aug.	Sept.	Oct.	Remarks.
1 a. m.	29.988	29.978	29.964	29.930	29.879	Falling barometer. Morning minimum.
2 a. m.	29.980	29.969	29.955	29.918	29.869	
3 a. m.	29.980	29.968	29.951	29.913	29.863	
4 a. m.	29.982	29.969	29.953	29.917	29.866	
5 a. m.	29.989	29.977	29.959	29.927	29.875	Rising barometer.
6 a. m.	29.999	29.990	29.969	29.938	29.888	
7 a. m.	30.007	29.998	29.976	29.951	29.901	
8 a. m.	30.012	30.003	29.982	29.962	29.913	
9 a. m.	30.014	30.007	29.987	29.967	29.921	Morning maximum.
10 a. m.	30.012	30.007	29.987	29.963	29.915	
11 a. m.	30.007	30.003	29.981	29.952	29.899	
12 m.	29.998	29.995	29.972	29.935	29.881	
1 p. m.	29.986	29.983	29.958	29.917	29.861	Falling barometer.
2 p. m.	29.976	29.971	29.946	29.905	29.850	
3 p. m.	29.966	29.961	29.939	29.898	29.847	
4 p. m.	29.965	29.959	29.937	29.890	29.852	
5 p. m.	29.972	29.962	29.942	29.905	29.856	Afternoon minimum.
6 p. m.	29.982	29.971	29.953	29.919	29.869	
7 p. m.	29.996	29.983	29.965	29.932	29.884	
8 p. m.	30.006	29.993	29.978	29.946	29.898	
9 p. m.	30.014	30.003	29.988	29.956	29.904	Evening maximum.
10 p. m.	30.020	30.007	29.992	29.956	29.906	
11 p. m.	30.014	30.001	29.985	29.951	29.898	
12 p. m.	30.002	29.990	29.974	29.942	29.810	
1 a. m.	29.988	29.978	29.964	29.930	29.879	Falling barometer.
2 a. m.	29.980	29.969	29.955	29.918	29.869	
3 a. m.	29.980	29.968	29.951	29.913	29.863	
Monthly mean.	29.994	29.985	29.966	29.934	29.883	

This table is based upon a record of three years, except for June, where only two years' record was used. The readings are from Richard's local standard barograph, seventy-fifth meridian time, and have been reduced to sea level. These variations are slight, but under ordinary conditions very regular. As may be observed from the above table, the average daily range is less than one-tenth of an inch. Any irregularity in the variations of the barometer from those just indicated should excite one to greater watchfulness, bearing in mind, however, that a north wind causes a rise in the barometer, while a south wind depresses it. If the barometer does not rise at the time it should, as indicated by this table, this is equivalent to a fall, and if it can not be accounted for as due to a south wind it must be regarded as suspicious; a falling barometer with a north wind is alarming. If the barometer does not show the diurnal changes as above indicated, the instrument must be regarded as very defective. Persons living in the hurricane region should either possess or have ready access to a good barometer and should make themselves familiar with its changes and the meaning thereof. It is a surprising fact that this instrument, invented in 1643, only came into use in the West Indies two centuries later. Westerby says:

It is a most remarkable circumstance that in the year 1831 the use of the barometer in giving notice of the approaching storms appears to have been little known or regarded in Barbados. Colonel Reid tells us that the only information he was able

to obtain relative to the fall of the barometer during the great hurricane in that island on the night of the 10th of August, 1831, was from a note written by Lieutenant Byrne, Fort Adjutant, in which he states that by 4 o'clock on the morning of the 11th, about the time the center of the storm was passing the north part of the island, the barometer had fallen below 28 inches, the average [normal] height being about 30 inches.

In an appendix to an interesting account of this hurricane, published in Barbados, there is a meteorological journal in which the height of the thermometer is given three times a day, but the barometer is never once mentioned. How the writer of that journal could be at all acquainted with meteorology, and not know the use of the barometer, is a matter of surprise.—Hand Book of the Hurricane Season, by G. W. Westerby, page 20.

CHAPTER V.

UNITED STATES WEATHER BUREAU IN THE WEST INDIES.

Although the essential laws upon which the West Indian hurricane is formed and moves have been known to meteorologists for a number of years and the necessity for warnings of the approach of these storms has been long recognized, yet, strange to say, there was never any extensive, systematic effort on the part of the nations most vitally concerned to collect the requisite data upon which to base a forecast and to issue and distribute the same for the benefit of the interests involved until the year 1898. In that year the Government of the United States took the matter in hand and appropriated the necessary funds for the establishment and maintenance of a sufficient number of thoroughly equipped meteorological stations in the West Indies to supply ample data for forecasting the hurricane as well as ample means for the distribution of all information relative thereto. This work, as undertaken by the United States Weather Bureau, was to some degree in the nature of an experiment, but the results accomplished during the three years of the existence of this branch of the service seem to have demonstrated beyond question the wisdom and the eminently practical value of the step taken. While the immediate and chief cause of this move on the part of the Government of the United States was the protection of its own interests, yet the benefits were not to be confined thereto, but the people and commercial and marine interests of all nations were to share the same on equal terms with the United States. The Bureau spares neither pains nor expense to protect and save, if possible, life and property without distinction of nationality. Hence a few words as to the *modus operandi* of this branch of the service may be helpful as leading to a better knowledge and a fuller appreciation thereof.

The United States Weather Bureau now (1901) maintains fully equipped stations at the following places in the West Indies, viz: Havana, Cuba; Cienfuegos, Cuba; Puerto Principe, Cuba; Santiago de Cuba, Cuba; Kingston, Jamaica; Santo Domingo, Santo Domingo; San Juan, Porto Rico; Basseterre, St. Kitts; Roseau, Dominica; Bridgetown, Barbados; Port of Spain, Trinidad, and Willemstad, Curaçao. These stations are in charge of trained observers and obser-

vations are made twice daily, at 8 a. m. and 8 p. m., seventy-fifth meridian time, throughout the year.^a During the hurricane season, June to October, inclusive, the morning observations are cabled promptly to Havana, the central station for the West Indian service. From Havana the combined reports are cabled to the central office at Washington. In addition to the reports from the regular Weather Bureau stations above mentioned, reports are received daily from British stations at Turks Island, West Indies; Nassau, New Providence; Hamilton, Bermuda, and from some along the Mexican coast. It will thus be seen that the region known as the "Great Bay of North America" is fairly well covered by these reports. The station at Havana, and in fact the entire West Indian service, is in charge of a forecast official under whose directions these reports are properly tabulated and charts drawn showing at a glance the general conditions existing over the region covered by the reports at the hour of observation. From this chart the forecaster can readily detect serious or significant departures from normal conditions and advise accordingly. It is scarcely possible for a severe storm to move over the Carribean Sea or the Gulf of Mexico without being detected at one or more of these stations. A storm approaching from the east is very apt to be detected some time in advance by its precursory manifestations at one or more of the outlying stations. The existence and location of a West Indian hurricane once determined, its subsequent movements are closely watched and all threatened districts forewarned so far as possible in ample time to take precautionary measures.

In deciding upon the most efficient means of serving the people, the Bureau deemed it best to issue two, and only two, kinds of messages to West Indian stations, and a failure on the part of the public in general to clearly distinguish between the significance of these two classes of messages has resulted in some confusion and unnecessary alarm. The messages issued by the Bureau are either "advisory messages" or "storm-warning messages."

1. Advisory messages are issued to such places as in the opinion of the forecaster are not threatened with dangerous conditions and are intended primarily for the benefit of mariners who may be leaving port. They are to be regarded by the public merely as a matter of information, and are not to be taken to mean that a storm is approaching. When unsettled conditions arise, and there is any evidence of the formation of a hurricane, these messages are sent out to inspire alertness on the part of observers in particular and the public in general. These unsettled conditions may and often do pass away without developing into anything serious. After the hurricane forms and starts on its devastating career these messages are sent out to reassure and inform

^a These arrangements have been altered by an order issued in January, 1902.

places not endangered. No signal whatever is displayed upon the receipt of an advisory message.

2. Storm-warning messages are issued whenever, in the opinion of the forecast official, a place is likely to be visited by dangerous conditions, and the hurricane signal—two red flags with black centers, placed one above the other—is always displayed upon the receipt of one of these messages. This message, of course, is to the public in general and means that it is advisable for all to prepare for severe weather.

Of course the Bureau is not infallible; it makes mistakes, so does the public. If, however, the efforts of the Bureau are properly understood and its messages correctly construed, its service will be more highly appreciated. It must be admitted that these advisory messages need to be worded with great care and disseminated with discretion because of a tendency on the part of the people to misunderstand them.

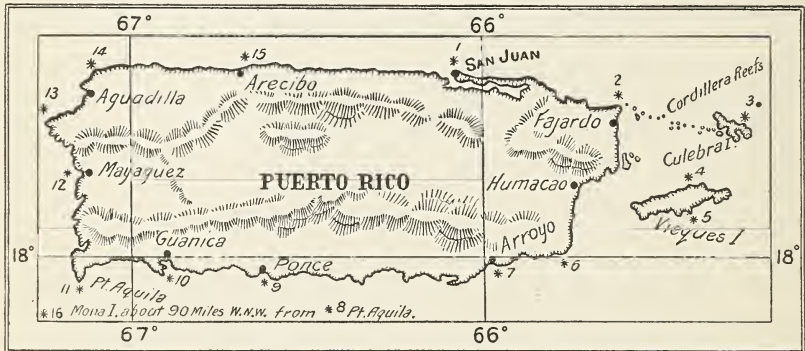


FIG. 6.

For the benefit of mariners visiting Porto Rican ports or navigating these waters, we will say a word relative to the service of the United States Weather Bureau in Porto Rico. In addition to the climate and crop work carried on in the island, a very effective local system for the distribution of information regarding West Indian storms is maintained. The central station for the island is at San Juan, from which point all messages are distributed. In the event of a storm the hurricane signal is displayed at the following places, viz: San Juan, Fajardo, Humacao, Arroyo, Ponce, Guanica, Mayaguez, Aguadilla, and Arecibo. (See map, fig. 6.) Moreover warning messages are sent to all telegraph stations on the island, and when a hurricane is expected the warning is carried by the police to the remotest parts of the island. The system is rendered doubly efficient through the generous cooperation of the insular telegraph company and the insular police force. Every effort is made to give the people a thoroughly efficient service.

Light-houses in and around Porto Rico.

Location.	Height.	Visibil- ity.	Character.	Inter- vals.	Structure.
	<i>Feet.</i>	<i>Miles.</i>		<i>m. s.</i>	
1. San Juan.....	171	18	W. F. & Fl	1 0	D, G. & W.
2. Cape San Juan.....	266	18	R. F. & Fl	3 0	D. G.
3. Culebrita	305	12	W. F.		
4. Vieques, North	68	8	R. F.		G.
5. Vieques, South.....	65	13	W. Flg	0 5	W.
6. Tuna	123	18	W. Fl	2 0	W.
7. Figuras	47	12	W. F.		G.
8. Muertos	297	18	W. F. & Fl	3 0	W. & L. B.
9. Ponce.....	46	10	R. F.		W. & B.
10. Guanica	119	8	W. F.		
11. Cabo Rojo.....	128	18	W. Rev	1 0	G.
12. Mayaguez.....	12	3	R. F. 2		
13. Jiquero	69	8	W. F.		
14. Borinquen	65	14	R. & W. Fl	0 30	R.
15. Arecibo	120	16	W. F.		W.
16. Mona	235	20	W. Rev	3 00	Bl.

NOTE.—The visibility is calculated for an elevation of fifteen feet above sea level, and is given in nautical miles. B signifies blue, Bl. black, D dark, G gray, L light, R red, W white, F fixed, Fl. flash, Flg. flashing.

The height is in feet above sea level. The intervals between the flashes are given in minutes and seconds of time.

This table is taken from First Annual Register of Porto Rico, 1901, page 26.

CHAPTER VI.

PORTO RICO AND ITS HURRICANES.

This island was known among the Indians by the name Borinquen, but when discovered by Columbus on November 16, 1493, he gave it the name San Juan Bautista, in honor of John the Baptist. Ponce de Leon, the discoverer of Florida, was its first governor. He took charge in 1509, establishing as his capital the town of Caparra (now called Pueblo Viejo), some 3 miles inland from the bay of San Juan. He afterwards changed his capital from Caparra to what is now San Juan, because the latter site could be more easily fortified and defended against the attacks of unfriendly Indians. He called his new capital Puerto Rico; subsequently and in some unknown way the island and the town changed names and to-day we call the island Porto Rico and the town San Juan. Spanish rule prevailed from the settlement (1509) down to 1898, a period of nearly four hundred years. The history of this period is a rather monotonous sequence of unimportant not to say uninteresting events.

The island is situated between latitudes $17^{\circ} 50'$ and $18^{\circ} 30'$ north, and longitudes $65^{\circ} 30'$ and $67^{\circ} 15'$ west. It is rectangular in shape, being about 100 miles long by 36 wide, and contains, approximately, 3,600 square miles. The census of Porto Rico, 1899, p. 11, says:

Passing across it from east to west, a little south of the middle of its breadth, is a broken, irregular range of hills or low mountains, which toward the eastern end trends northeastward, and terminates near the northeastern corner of the island, where it culminates in the peak of El Yunque, 3,609 feet in altitude. Elsewhere it ranges in altitude from 2,000 to 3,000 feet, with occasional summits slightly above 3,000 feet and gaps slightly below 2,000 feet. This range is known in different parts of the island by various names, Cordillera Central, Sierra de Cayey, and in the northeast Sierra de Luquilla. From its crest the land slopes northward and southward in broad undulations, deeply cut by streams, giving most of the interior of the island a steep, hilly surface, gradually becoming more nearly level until near the coast it spreads into broad, level playas. This range forms the water divide of the island, and from it streams flow northward and southward, those flowing north having much the longer courses and gentler slopes. None of these streams are navigable, excepting for a very few miles near their mouths, where they are in effect estuaries. The largest are the Rios Loiza, Bayamon, Morovis, Arecibo, and Blanco, all on the north of the dividing ridge. On the south the dividing ridge descends steeply, with short spurs to a narrow coastal plain. Here the streams are short, with very steep descents.—Census of Porto Rico, 1899, p. 11.

About 24 per cent of the area of the island is under cultivation, the principal crops being sugar cane, coffee, and tobacco.

With these introductory remarks we will proceed with the chief aim of the chapter—the presentation of a few facts concerning some of the most destructive hurricanes which have visited the island. No little difficulty has been experienced in compiling the following list, owing to the fact that early chroniclers of Porto Rican events paid only incidental notice to these visitations, oftentimes passing them by with a mere mention. Only the unusually destructive ones received a detailed treatment, and this, of course, in a descriptive way. The data given below are taken from various sources, and are believed to be as complete as existing records warrant. In translating the Spanish into English the chief aim has been to give all the material facts only; hence the accounts are not to be regarded as efforts at literal or even full translations.

The principal authorities consulted were: *Memorias de Puerto Rico* por D. Pedro Tomas de Córdova (referred to as “Mem.”); *Historia de Puerto Rico* por José Julian de Acosta y Calbo (referred to as “Hist. de P. R.”); *Efemerides de la Isla de Puerto Rico* (referred to as “Efem.”); *West Indian Hurricanes*, Bulletin H, by Professor Garriott (referred to as “B. H.”).

1515, July.—The royal officers reported to the spanish king that a storm had caused the death of many Indians.—Hist. de P. R., p. 433.

1526, October 4.—Dr. Juan de Vadillo describes this storm thus: On the night of October 4 there began on the island such a storm of wind and rain, called here a hurricane, as to destroy the greater portion of this city, and to do great damage to the estates in the country by overflowing the rivers. The loss can not be estimated; many rich have become poor, among them Pedro Moreno, the lieutenant-governor.—Hist. de P. R., p. 433.

1527, October 4.

1530, July 26, August 23, August 31.—Within a month and a half there have been three hurricanes, which have destroyed all farm work, drowned many cattle, and created great distress among the people. In San Juan half the houses were blown down and the best of those remaining had no roofs. Not a house was left standing in the country. All have been left poor and now wish to leave the island.—Hist. de P. R., p. 123.

1537, July and August.—Within two months we have suffered from three hurricanes, the greatest ever experienced. As the plantations are situated along the rivers, the crops were destroyed by the overflow. Many slaves and cattle were drowned, great destitution prevails, and the desire to leave the island is now more general.—Hist. de P. R., p. —.

1568, August 24.

1575, September 21.—(San Mateo.)—Hist. de P. R., p. 434.

1615, *September 12*.—This was the severest hurricane of the forty years following that of San Mateo. It did so much damage to the cathedral that it was necessary to cover a portion of it with grass [thatch] until aid could be received from the King.—Hist. de P. R., p. 434.

1738, *September 12*.—On this day the island was visited by one of those storms which have ever caused such ravages. The hurricane destroyed the crop of wild fruits—the main support of the swine and other animals. The sudden overflows drowned a great number of live stock; the citizens of Ponce and Coamo abandoned those places because of the misery to which the storm reduced them; they were compelled to eat unwholesome roots, which caused much sickness, and as the Government allowance (for relief) for that year was exhausted, the treasury was bound in the sum of 50,000 pesos, which fact aggravated the situation and made it less possible for the Government to succor the needy and restore the loss. The storm was followed by another very serious calamity in the form of a plague of worms, which seemed to originate in the mud-covered swamps and destroyed all seeds as fast as planted.—Mem., v. 3, p. 22.

1740.—A hurricane destroyed a palm grove 5 or 6 leagues in extent at Ponce.—Hist. de P. R., p. 434.

1751, *August 18*.—No details.

1766, *September 19*.—No details.

1766, *October 7 and 8*.—This hurricane left in ruins the following towns, viz: Cangrejos, Rio Piedras, Loisa, Fajardo, Caguas, Las Piedras, and Guayama; all crops of rice, corn, and yucca were destroyed; overflowing rivers did great damage; the houses and huts in the country were destroyed or badly damaged; no fruit trees were left standing; the roads were rendered impassable; many ships were wrecked and the few that escaped the storm were used by the Government in the saving of life and property and carrying aid to the destitute. Without the least doubt this is one of the most destructive hurricanes that has visited the island.—Mem., v. 3, p. 29.

1767, *August 7*.—Porto Rico experienced a strong gale which destroyed the plantations, and much live stock perished in the overflowing rivers. This event and the lack of funds for relief placed the people in the same miserable state as the year before.—Mem., v. 3, p. 31.

1772, *August 31*.—The convent of Santo Domingo, Forteleza de Santa Catalina, the chapel at Moro, and many other buildings were unroofed and many buildings materially damaged. Six ships were sunk and eight others stranded; all crops destroyed and many animals perished. Roads were rendered impassable.—Mem., v. 3, p. 36.

1775, *August 1*.—A furious hurricane.—Mem., v. 3, p. 40.

1776, *September 7*.—A strong hurricane.—Efem., p. 92. Mem., v. 3, p. 40.

1780, *June 13*.—A hurricane caused great destruction of property, especially of crops. An English war ship driven from St. Lucia was wrecked on the coast of Guayama.—Mem., v. 3, p. 42.

1785, *September 25*.—A furious hurricane passed over the island.—Mem., v. 3, p. 5. Efem., p. 94.

1788, *August 16*.—B. H., p. 24.

1804, *September 4*.—A great hurricane.—Efem., p. 91.

1804, *September 21*.—A great hurricane known as "San Mateo," which long remained in the memory of the people.—Efem., p. 94.

1806, *September 11*.—The south portion of the island experienced the severest hurricane for many years past; many churches and a large portion of the houses in that section were damaged; fruit trees destroyed; rivers overflowed their banks, destroying much property. At San Juan shipping suffered much loss.—Mem., v. 3, p. 153.

1807, *August 17, 18, and 19*.—The island again suffered the disasters of a severe hurricane from the east which lasted fifty hours. Thirty-six rivers overflowed, destroying much property and live stock. Three Danish ships which were anchored at St. Croix were stranded on the coast of Porto Rico and an English cutter of 18 cannon which was cruising between Porto Rico and Vieques was wrecked and only one of the crew saved.—Mem., v. 3, p. 154.

1809, *September 2*.—B. H., p. 24.

1812, *July 23, August 21*.—Heavy gales did considerable damage to crops.—Mem., v. 3, p. 183.

1813, *July 23*.—The storm of this year was most severe at San German and Yauco.—Hist. de P. R., p.

1814, *July 23*. No details.

1814, *August 11*.—For an account of this hurricane see "Diario Economico del Intendente Ramirez" of August 11, 1814—Hist. de P. R., p. (I was unable to find the book referred to.—W. H. A.)

1816, (?) 18, 19, and 20.—A hurricane of extraordinary violence visited the island this year. In the port of Caborojo three ships were wrecked and a portion of the crew perished. In the town of Tuna the wind destroyed 72 houses and seriously damaged crops. Two persons were killed and a great number of cattle. In the village of San German the overflowing river destroyed 101 houses, 82 head of cattle, 6 horses, 119 hogs, and many domestic birds. In many other towns of the south and west portions of the island there was great destruction of property.—Mem., v. 3, p. 258.

1819, *September 21 and 22*.—In the midst of so many afflictions occurred one of the most dreadful and destructive of the hurricanes that have visited the island. It began on the night of the 21st and ended at midday of the 22d. The people were thrown into the greatest confusion and were reduced to the greatest misery. All the ships that were in port were wrecked; the greater part of the houses both

in the town and in the country was destroyed, crops were ruined, sugar and coffee mills were destroyed; the whole presenting a sad picture of desolation.—Mem., v. 3, p. 355.

1825, July 26 and 27.—(Santa Ana.) On the night of the 26th and 27th, the island was visited by one of those terrible manifestations of nature occasioned by the winds which frequently change the face of the earth, chiefly in Arabia and Africa, and which are a scourge in the Antilles, Madagascar, and many other countries.

Two days before copious rains had been experienced and early in the morning of the 26th violent gusts of wind had been felt; but the atmosphere cleared up at intervals and the only indication during the day of the weather that set in at night was the excessive heat felt at those intervals when the rain ceased. At 8 p. m. the sky began to be overcast with dense clouds and the wind grew stronger and from the summits of the mountains of Luquillo serpentine flames of fire seemed to issue. Lightning flashes became more frequent and the rain fell in torrents. At 11 p. m. there was no doubt that a terrible hurricane was on. The clouds which could be distinguished in the zenith had in their centers dark spots and were bordered with a copper color. The winds were gradually increasing in strength.

From the afternoon, according to the best informed, the wind blew from the east and northeast, but at 11.30 p. m. it began with greater fury than ever from the same directions, inclining a fourth more or a fourth less in the quadrant mentioned until 2.15 a. m., when it changed to the north-northwest, where it remained until 2.45 when it suddenly shifted to the southwest and successively to the south, south-southwest, and southeast, where it remained until 8.30 a. m. of 27th, after which it abated.

The devastations were extraordinary in some places. The governor's palace was badly damaged, the San Antonio bridge and other public and private buildings were thrown down and two suburbs almost entirely wiped out. All communication between San Juan and the island was destroyed, a part of the city wall suffered damage; the lightning rod on the powder magazine was destroyed; also many doors and windows. All the ships in the bay were driven aground. The towns on the south and west portions of the island did not suffer much but those in the north and east sustained great loss. An official report gives the losses as follows, viz:

Total deaths	374
Total injured	1, 210
Houses blown down	6, 710
Live stock killed	2, 560
Fowls killed	11, 345

Many crops destroyed.

Total value of property lost, 481, 112 pesos.

(This is one of the truly historic hurricanes of the island.—A.)

1827, *August 17*.—A hurricane caused great loss of crops, loss of five ships at Ponce, 3 at Guayama, 2 at Humacao, 1 at Mayaguez, and 1 at San Juan. Not a plantain tree remained.—Mem., v. 5, p. 201.

1837, *August 2*.—(La Reina de Los Angeles: The Queen of the Angels.) This hurricane was remarkable for its excessive violence. It lasted only five hours, during which time all the ships in the harbor of San Juan were wrecked and great damage done to property throughout the island.—Hist. de P. R., p. 434.

1851, *August 18*.—A rather mild hurricane; caused some damage.—Hist. de P. R., p. 434.

1852, *September 22-26*.—B. H., p. 25.

1867, *October 29*.—(San Narciso.) We now come to a consideration of one of the most remarkable, if not the most remarkable hurricane in the annals of Porto Rico, that of San Narciso. The following notes are taken from a work entitled *La Memorable Noche de San Narciso*, por Don Vicente Fontan y Mera, published in 1868, the year after the hurricane. The order of treatment here followed is the same as in the work above referred to; that is, brief extracts from the reports (mainly official) from the various towns on the island. This storm appears to have passed diagonally across the island, the center passing over Caguas, a town in the east central part of the island. The injured towns are described in alphabetical order, as follows:

Adjuntas.—Storm began at 8 p. m. with strong gusts of wind from the north; afterwards from the east; finally from the south, from which direction it blew most furiously until 3 a. m., when it began abating. There were 2 deaths; 300 houses, a large portion of the huts, and 4 bridges destroyed.

Aguada.—Storm began at 9 p. m., accompanied by heavy, copious rains, thunder, and lightning. At 1 a. m. the wind was blowing furiously from the south, but by 3 a. m. it had abated. Very few of the houses were able to resist the fury of the winds. More than two-thirds of the houses were rendered useless. One death.

Aguadilla.—Day began serenely. At 7 p. m. the sky was covered with dark clouds and light showers began to fall. By 10 p. m. the wind was so heavy that it threatened to destroy all. The people of the village became terrified; the lamentations of those living in the country could be distinctly heard; those living near the sea were thrown into great consternation by the terrifying noise of the sand carried by the winds and falling upon the roof. One death; 1 stone house, nearly all the wooden houses, and all the huts were thrown down.

Aguas Buenas.—Torrents of water came from the hills; the force of the wind moved the very foundations of the houses; the church, houses, huts, and plantations of cane, rice, coffee, and corn were handled in a most horrible manner, and on every side were to be seen lakes, mud, wreckage, and misery. There were 11 deaths.

Aibonito.—As the night approached the wind was fair, but in a very short time it began to blow with great fury; at 7 p. m. the town was completely enveloped in the horrors of a terrible hurricane. There were 4 deaths.

Añasco.—There was 1 death and great loss of property.

Arecibo.—There was 1 death; some houses unroofed; many huts thrown down, and 1 ship damaged.

Arroyo.—The day broke clear and calm. At 2 p. m. it began to grow dark. All observing persons noticed this strange phenomenon and concluded at once that some-

thing serious was about to happen. The barometer pointed to "hurricane;" the sea was heavy; the winds continued to increase in strength, and by 6 p. m. the town was suffering the full effects of a horrible hurricane. The wrath of the elements did not cease, and profound darkness reigned everywhere. The streets were deserted, and only the sound of the hammer could be heard—a sure sign that the people were making fast doors and windows. In the suburb of Guamany almost all the houses were thrown down. By 10 p. m. the hurricane was over. Two persons were wounded and many large houses unroofed.

Barranquitas.—The effects of the hurricane were terrible. People of the town who have memories of the storm of the "Queen of the Angels" affirm that the calamities of 1837 can not be compared with those of 1867. The winds blew from the west during the p. m., but toward night changed to the southeast, and then began the devastations of the hurricane. Darkness, thunder, lightning, and the noise of the wind clothed nature with a false aspect. It seemed that the rushing of the waters and the whirling of the winds would destroy all. On the following day were to be heard only the wailings of the unfortunates. The coffee crop, the hope of the farmer, was ruined. There were 5 deaths, 20 wounded, and 300 houses and 550 huts thrown to the ground.

Barros.—Hurricane began at 6 p. m. of the 29th and lasted until 1 a. m. of the 30th. At 9 p. m., when the wind was at its worst and the people were already thoroughly confused, they were suddenly made to realize that they were surrounded on the south, west, and north by the waters from the river. They now became panic stricken. The water rose 6 varas above its normal level.

Bayamon.—Six persons perished and 14 were more or less seriously hurt.

Caguas.—During the morning the heat was suffocating—very unusual for the season. At noon the sky began to be overcast with dense leaden-colored clouds, which continued to gather, so that by 4 p. m. the town was enshrouded in darkness. At 5 the action of the wind and the falling of the barometer indicated the approach of a hurricane. The gusts of wind continued to increase in violence, so that by 7:30 p. m. the force of the wind was almost irresistible. At the beginning the wind blew from the north, and after a calm of 10 or 12 minutes it changed to the southeast. The hurricane was now on in all its fury. The rain fell in torrents, the wind shook the houses in a most frightful manner, buildings were stripped, the tiles were carried to great distances, great trees were uprooted, and walls of masonry razed to the ground. To complete the awful scene there was a shaking of the earth sufficiently severe to reduce to rubbish some of the interior walls of the best dwellings and the most solidly constructed. The hurricane lasted in all its fury until 9:30 p. m. and was entirely over by 11 p. m. The rain continued until 1 a. m. Eleven persons were killed, 103 wounded, many stone buildings damaged, nearly all the wooden ones unroofed, and most of the huts blown down.

Carolina.—One person killed, 6 wounded, the church damaged, 1 stone house blown down, many unroofed, and almost all the huts demolished.

Cayey.—The wind first blew from the northwest; rain fell in torrents; by 8 p. m. it was evident that a true hurricane was on. The noise of the water which fell like a cataract, the continuous lightning flash, and the impenetrable darkness inspired the gravest apprehensions. As fright and confusion occupied the minds of all, it was not possible to tell how long the wind blew from the west, but it came with such force as to strip and uproot the great trees and destroy many houses. From the west the wind shifted to the south, from whence it seemed to come with all the fury of the infernal regions, so much so that it seemed as if the hour of total destruction of all things had come. No one is able to give a correct idea of those hours of terror, fright, consternation, and death. Only 2 deaths reported.

Ceiba.—The oldest inhabitants affirm that this hurricane for its duration, intensity, and ravages makes less memorable that of Santa Ana. Many houses were rendered useless and 77 huts destroyed.

Ciales.—The terrible event of this day has spread desolation and misery in this town. The morning appeared rainy and the sky was overcast with dense clouds. At 6 p. m. the winds came in light gusts; at 10 the storm began, and then there was presented to view a picture of horrible desolation. The doors and windows were lifted from their hinges, and the people in desperation ran quickly hither and thither seeking a place of refuge, but finding none. In a word, chaos reigned among the people.

The storm lasted six hours and was most destructive during the first part. Mothers with their children on their backs might be seen endeavoring to find a place of safety to escape death. The darkness was so intense that it was impossible to discern objects, and only by the agonizing cries of the victims could they be located in order to render aid. There were 3 deaths and 29 wounded; all the houses were blown down.

Cidra.—At 7 p. m. the wind began to blow from the northwest. Soon after it developed hurricane force, lasting four or five hours. The earth trembled, the noise of flying fragments of zinc torn from the roofs by the wind and carried to great distances, and the appearance of the sky filled with large clouds, presented a scene calculated to fill the minds of the people with consternation. When the light of the following day revealed the ravages of the storm all minds were filled with sorrow and pity. Four persons were killed and 14 injured; 50 houses and 340 huts were blown down.

Coamo.—The effects of the hurricane were serious. From 7 to 10 p. m. the winds lashed the town with unheard-of fury. At first the wind came from the southwest but changed quickly to the south and southeast. The first moments produced the gravest fears. Black clouds covered the whole sky and perfect darkness reigned. The peals of thunder and the lightning flashes on this sad night increased the alarm. There was one death, four injured, and some property lost.

Corozal.—At 7:30 p. m. the wind began to rage with frightful fury. The noise of the elements produced terror and consternation; perfect darkness prevailed everywhere, and only by the momentary flash of lightning were the frightful scenes revealed. By 9:30 p. m. the storm had nearly ceased. One death, 37 injured, and many houses damaged or destroyed.

Fajardo.—At daybreak there were some clouds, but these were not regarded as ominous. At 5 p. m. the winds began to blow in a most unusual manner and with an almost irresistible force. The water fell in sheets, inundating all; the earth trembled twice. Only the direful noise of the hurricane, the crash of falling buildings, and the cries of the unfortunates who experienced every degree of misery, from poverty to death, were to be heard. Three hours afterwards, the strife of the elements having ceased, the bravest hearts went forth seeking their families and rendering aid to the needy. The greater part of the houses was on the ground and passing along the streets was impossible because of the piles of débris which but a short time before had constituted the humble homes of the poor. There were 13 deaths and 113 injured.

Guabo.—There were 19 killed and 40 wounded. Twenty houses and 400 huts were blown down.

Hato Grande (San Lorenzo).—There were 5 deaths, 13 wounded, 183 houses blown down, and more than 500 huts destroyed.

Humacao.—At 4:30 p. m. the wind began to blow from the northwest, accompanied by light showers. For a moment all believed that it was only an ordinary change, but, vain delusion, at 5 p. m. a hurricane more violent than any in the annals of this town was upon us. The wind raged in a most unwonted manner; the most solid buildings were shaken to their foundations. All houses were unroofed and many completely demolished. The wind changed to the south and an earthquake came to add terror to the scene. Profoundest darkness reigned everywhere. Few houses remained intact after the storm. One person killed.

Luquillo.—At 4 p. m. the wind blew from the north in such a manner as to give warning of an approaching hurricane. The wind increased for a time, accompanied by some rain. At 5 p. m. it shifted suddenly to the northeast. At this moment an earthquake occurred; the rain increased; the impetuosity of the wind and water was soon converted into a frightful hurricane. After 4 p. m. the people abandoned their homes and sought refuge in stronger buildings. At 5 p. m. it was not possible to resist the storm. Seven were killed and 16 wounded.

Manatí.—Nineteen persons were killed.

Mayaguez.—There were 9 deaths, 15 stone houses badly damaged, and 150 huts demolished.

Moca.—As night approached neither frequent showers nor northerly winds pre-saged the coming storm. Notwithstanding this, the people retired to their homes, because they were no longer able to walk the streets. Copious rains and vivid lightning foretold the coming storm. At 10.30 p. m. the thunder ceased, the rain increased, and the frightful noise of the hurricane was manifest. The storm continued its work of devastation until 3 a. m. of the 30th. Two persons were killed.

Moróris.—At 7.30 p. m. the effects of the hurricane began to be felt. Words can not convey the consternation and confusion which prevailed. Some silly people believe that at times it rained fire; at other times, water; and the most religious, that the hour of final judgment had come. Nine persons killed and 36 wounded.

Naguabo.—Eight deaths, 48 wounded; many houses ruined; three ships sunk, cargoes lost, crews saved.

Patillas.—About 6 p. m. thousands of swallows were to be seen, the clouds were moving rapidly, and the atmosphere was heavy, so that anyone given to observing might have known by these signs that a storm was approaching. The wind blew from the northwest at first, afterwards from the southwest. Never in the memory of the inhabitants has there been felt such violence of wind, especially from 7 to 9 p. m. During those two hours of affliction and desolation many houses were wrecked and two lives lost.

Ponce.—Three killed, 32 wounded, much stock lost, and great property loss.

Rio Grande.—There were 12 deaths; more than 100 houses and 300 huts blown down.

Rio Piedras.—One killed, 3 wounded, 126 houses and 100 huts demolished.

Salinas.—At midnight of the 29th the storm suddenly came upon this town. The great trunks of the hucar were as fragile cane; the light of a meteor illuminating space for an instant inspired grave apprehensions, and all feared for their lives, because at 2 a. m. the water from the river invaded the greater part of the town. Agricultural products suffered the greatest damage.

San Juan.—At 5.45 p. m. the barometer read 29.60 inches, and such was the state of the atmosphere as to give to the close observer ominous signs of an approaching disaster. By 7.15 all the elements seemed to have been unloosed and the city was in the midst of a frightful hurricane. The darkness of the night, the torrential rains, the impetuosity of the winds, the clatter of doors and windows, and the trembling of the buildings inspired serious cares in the minds of all. On the streets were to be seen only those persons who had public duties to perform or those whom the fearful night had caught away from home and who were trying to return. These were few, however. The streets were currents of water, which the winds drove in different directions, and the hurricane from the first enshrouded the city in darkness. The street lamps for the most part were useless, and all those who found themselves in the streets ran quickly toward their homes whenever the fury of the wind did not force them to take another direction.

The ships in the bay felt the full force of the hurricane and suffered much damage. Sr. Tosta, the captain in actual command of the port, makes the following report of the disasters among the ships, viz:

"The sloop *Carmen* was dismasted at 7.30 p. m. and was instantly sunk.

"The Spanish pilot boat *Josefita* was dismasted at 8 o'clock and went down immediately thereafter.

"The sloop *Rita* was sunk at the same hour, carrying with it the boat belonging to the captain of the port. Several trans-Atlantic ships broke away from the east wharf, where they were fastened. The rings which held the ropes were torn away.

"The Spanish brigantine *Joaquin* was driven onto a bank, but finally succeeded in getting off without serious damage.

"The frigate *Apollo* was grounded; also the English schooner *Maria*.

"The pilot boat *Fé* grounded in the arsenal and was completely dismasted.

"At 9.30 the boats belonging to the health officer and custom officer went down."

From that hour the wind began to blow from the east and the barometer to rise, and by 11.30 the wind was blowing "a fresh breeze," as is said in nautical terms.

The property loss in the city was not very considerable, owing perhaps to the manner of constructing the houses. The houses are securely joined one to another.

Trujillo Alto.—There were 13 killed, 69 wounded, and great loss of property, 12 sugar mills being wrecked.

Utuado.—From 9 a. m. there occurred at short intervals heavy showers accompanied by gusts from the north. By 9.30 p. m. the hurricane was on in all its fury. It raged until after 11 p. m. Four persons were killed and much property destroyed.

Yauco.—Very heavy, strong winds began to be felt at 5 p. m. and by 8.30 p. m. the hurricane was furiously lashing everything, destroying the cane and the coffee, the main support of this section.

Summarizing the reports rendered from 67 towns, I find there was a total of 211 deaths, 741 persons more or less seriously injured, and a total estimated property loss of 6,397,802 pesos.

(For an excellent account of this same hurricane as it affected the island of St. Thomas, see Bulletin H, p. 52 and 53.—W. H. A.)

1888, *September 5*.—Dr. Branch.

1889, *September 4*.—B. H., p. 36.

1899, *August 8*.—(San Ciriaco.) The following account is taken from Bulletin H, pages 53–54, and was prepared by R. M. Geddings, section director, Weather Bureau.

Porto Rico has been devastated by many hurricanes, but the records, beyond the mere statement of the facts, are very incomplete and inaccessible. Four, however, stand out prominently as having committed terrible ravages. These are the hurricanes of Santa Ana on July 26, 1825; Los Angeles on August 2, 1837; San Narciso on October 29, 1867; and San Ciriaco on August 8, 1899.

Owing to the paucity of records it is almost impossible to say which of these four was the most severe, but it is the generally conceived opinion that that of the Los Angeles was the worst. There being no meteorological data available, however, it can probably be said that the hurricane of San Ciriaco was very nearly as severe as regards the velocity of the wind, and very much more so as regards the destruction of property and life. This is probably due to the fact that in 1837 the population of the island and the number of buildings was very much less. The latter hurricane having also occurred while a station was in operation in San Juan, we are enabled to present meteorological data which is entirely wanting in the former.

The rainfall during San Ciriaco was excessive, as much as 23 inches falling at Adjuntas during the course of twenty-four hours. This caused severe inundations of rivers, with which Porto Rico is so liberally endowed, and the deaths from drowning numbered 2,569, as compared with 800 killed by injuries received from the effects of the wind. This number does not include the thousands who have since died from starvation. The total loss of property was 35,889,013 pesos.

For several days previous to the hurricane the meteorological conditions had been peculiar. On the 3d calm was recorded at both the morning and evening observations. Between midnight of the 3d and 8 a. m. of the 4th but 4 miles of wind were recorded. The barometer showed no rise such as is usually anticipated immediately preceding a hurricane, the mean of the 5th being 29.96, and that of the 6th 29.98. During the afternoon of the 7th the sky was unusually hazy, and the lower clouds were moving rapidly from the northeast. About 3 p. m. the sky was covered with thick alto-stratus and stratus clouds, the former moving from the southeast and the latter from east-northeast. At this time the barometer registered 29.865. At 10 p. m. the barometer began its downward movement, which did not cease until the lowest reading, 29.23 inches, was reached at 8.30 a. m. of the 8th, at which time the mercury in the tube was oscillating violently.

The storm passed to the south of San Juan, and, striking the island on the southeastern part, passed in a direction north of west until it passed the northwestern part, the time consumed in its passage being from 7 a. m. until 1 p. m. The wind reached no very high velocity until 2 a. m. of the 8th. At 10 p. m. of the 7th, however, it came in puffs, some of them of considerable violence. At 5 a. m. of the 8th it was raining and blowing furiously, both increasing until between 7 and 9 a. m. the hurricane was at its height, the wind reaching a registered velocity of 66 miles an hour from the northeast. The wind shifted during the progress of the hurricane from northeast to southeast.

There was noted in the case of this hurricane, as has been noted in subsequent ones, a decided lowering of the relative humidity immediately preceding.

CHAPTER VII.

ST. KITTS AND ITS HURRICANES.

The little island of St. Kitts (St. Christopher), West Indies, was discovered by Columbus in 1493, was settled by the English in 1623 and soon afterwards by the French, with whom the English generously divided the island. It has more than once been a factor in international disputes and much blood and treasure sacrificed for its possession. It finally, however, came into the undisputed possession of England, and there remains to this day. St. Kitts boasts of the fact that she is the oldest English colony in the West Indies and that from her many of the others were settled.

The main body of the island has an oval form, from the southeast end of which runs a narrow neck, gradually expanding into a small knob. The total length of the island is 23 miles and the breadth of the main body or oval about 5 miles, giving a total area of 68 square miles. The central part of the main body is occupied by a range of lofty rugged mountains traversing it from southeast to northwest and attaining its greatest height, 4,100 feet, at Mount Misery, with a secondary elevation of about 3,200 feet near the southeastern end. The mountains appear to be crowded together and are intersected by rocky precipices. The circle of land formed by the skirts and lower slopes of the mountains of the main body of the island and the valley of Basseterre constitute nearly the whole of the arable and cultivated portion of the island. These tracts of land are covered with sugar plantations and dotted over in every direction with homesteads, mills, and laborers' villages. The higher slopes of the mountains are clothed with short grass, affording excellent pasturage, while their summits are crowned with dense woods. The island is unquestionably of igneous origin; the soil is a dark gray loam, very porous, and one of the very best in the West Indies for the production of sugar. The climate is dry and healthful, being tempered and purified by the winds, electric storms, and hurricanes to which the island is exposed because of its position. The evenings and mornings of the hottest days are pleasantly cool. The coolest months are January and February, the warmest, August.

In the present chapter we have collected as much information as could be had relative to the hurricanes and floods of the island which, because of their excessive violence and disastrous consequences, have found their way into records of one form or another. Details are always given if accessible.

The abbreviations used in this chapter in referring to the authorities for the various accounts are as follows, viz:

S. C.—Southey's Chronological History of the West Indies.

B. H.—Bulletin H, U. S. Weather Bureau, by Professor Garriott.

W. J. B.—Dr. W. J. Branch, of St. Kitts.

Notes.—A miscellaneous collection of notes.

The accounts of the two hurricanes of 1899 were written by myself and were first published in the Monthly Weather Reviews for August and September, 1899, where more extended accounts may be found

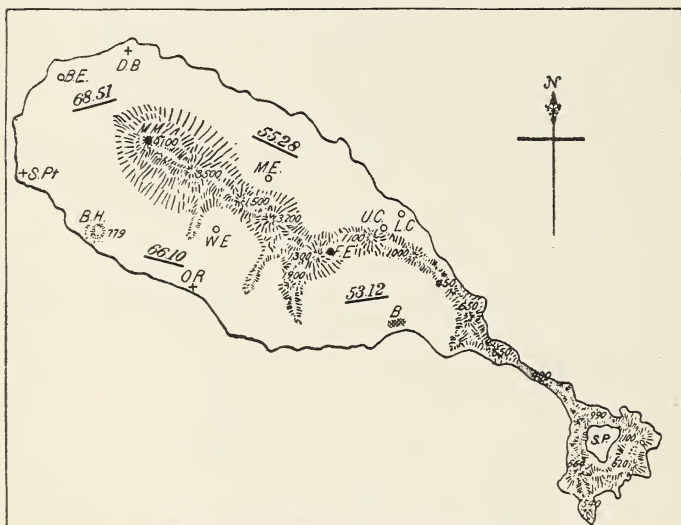


FIG. 7.—Island of St. Kitts, West Indies.

B., Basseterre, the capital and chief town, lat. $17^{\circ} 18' N.$, long. $62^{\circ} 48' W.$; location of U. S. Weather Bureau station. O. R., Old Roads, a small village where it is said Columbus made a landing and which for a long time was the capital of the English part of the island. B. H., Brimstone Hill, at one time a celebrated fortress. S. Pt., Sandy Point, a small village. M. M., Mount Misery, an extinct volcano, about 4,100 feet high. S. P., Salt Pond. W. E., Wingfield Estate. M. E., Molyneux Estate. L. C., Lower Canada. U. C., Upper Canada. F. E., Fountain Estate. B. E., Brotherson Estate. D. B., Dieppe Bay, a small village.

The figures 66.10, etc., underlined, show the average annual rainfall in inches for the four regions of the island. The small figures, not underlined, show the altitudes of the corresponding locations, expressed in feet, above sea level.

1623.—On September 19 a hurricane destroyed the tobacco crop on the island of St. Christopher, this being the first crop planted and raised by the newly arrived colonists.—S. C., vol. 1, p. 252.

1625, September 19.—B. H.

1642.—During this year there were three hurricanes in the West Indies; the second lasted twenty-four hours, during which, at St. Kitts, 23 fully laden vessels were wrecked upon the coast, all the houses blown down, and the cotton and tobacco crops completely destroyed, and the salt ponds overflowed and rendered unproductive for some time.—S. C., vol. 1, p. 294.

1650.—No date.

1652.—No date.

1666.—August 4 and 5.

1667.—September 1, a tremendous hurricane devastated the island of St. Kitts; it began at 9 a. m. and lasted until 5 p. m. from the north, then shifting to the south, blew with such violence that all the houses and buildings were thrown down. The inhabitants sought shelter from its fury by throwing themselves upon the ground in the fields.

M. Laurent, the governor, in a letter to M. Colbert, says:

There has blown here the most violent hurricane ever known, and I hold myself obliged to inform you that this island is in the most deplorable state that can be imagined, and that the inhabitants could not have suffered a greater loss, or been more unfortunate, except they had been taken by the English. There is not a house or sugar works standing, and they can not hope to make any sugar for fifteen months to come. As for the manioc, which is the bread of the country, there is not one left, and they are more than a year in growing. I can not describe to you, sir, the misery of this poor island without wounding my heart. It is as a place over which fire has passed. I assure you that if peace is not made, or men-of-war sent into this country to facilitate the bringing of cassava from the other islands, that the inhabitants and troops will die of famine. I shall do everything in my power to keep up the spirits of the inhabitants, who are stunned like men who are totally ruined, and I shall not spare either pains or trouble to maintain the island and remedy the evil, which is irremediable except succor arrive from without.—S. C., vol. 2, p. 78.

The hurricane of September 1, 1667, seems to have been the severest one in the history of St. Kitts.

1681.—The island of Antigua was desolated by a tremendous hurricane.

The following account of two hurricanes which occurred at St. Kitts in 1681 is from a letter written soon afterwards and published in the first volume of *A Young Squire of the Seventeenth Century*. It seems so quaint and interesting that its reproduction verbatim et literatim is justified in this connection.

Saturday the 27th of August, about one or two in the morning, the winds blew very hard at northeast, which did small damage. Before day, the weather broke up with appearance of fair weather; but before nine of the clock, it was overcast and proved a rayney, blustering day. About eight or nine o'clock at night the wind, veering more to the north and from the north to the northwest, increased till midnight; at which tyme it blew so vehemently hard, and so continued with small rayne and frequent lightnings, until within less than an hour of daybreake (when the storm began to cease), that I had not a house standing upon my plantation, in which I could shelter myself from the weather.

It was a little after midnight, when a great part of the roof of my dwelling-house began to fly away; several of my out-houses being already downe. Then I thought it tyme to shift for myselfe; which I did. Turning my people out before (who had been driven to my house by the insufficiency of their houses) I locked the door, and tooke the key in my pocket.

I could not goe against the winde; and with no small difficulty could I goe with it, for fear of being driven away by it. At last we got (all but one of our company) to a little hut, which, we had agreed upon before, to make our rendezvous in; which sheltered vs from the violence of the storme, but not of the raine, the thatch being partly blown away. But to be wet was then no news to vs. Wee were in continual

feare oure little cottage should have beene blowne away; which rocked like a cradel. As soone as the storme began to cease, I went up to my house whiche I found miserably torne, and flat with the ground. My sugar-worke, in like manner, and all my buildings. I walked downe to my new sugar-worke, which I had built not long before, about a quarter of a mile or more from my house, towards the sea, to make my tenants' sugar canes; to whom I had leased fifty acres of land, and had newly begun to make sugar at it, and was then boiling at it, when the storme began. I found *that* likewise flatt with the ground, the stone wall overturned, and the timber scattered in divers places farre distant from the house.

I must confesse, I did wonder more to see my house standing, than to see what was destroyed, considering the impetuosity of the weather. I had scarce time to view this losse, when the winde being shifted into the south, the storme began afresh. I made what diligence I could (the pathes beeing all spoyled), to get to the place where my dwelling-house did stand; to whiche the winde assisted me, being in my back, but veering to the southeast.

It blew a frett of winde, and continued with suche violence for severall hours, that it did much more damage in some partes of the island than the fore-part of the storme. But it was not comparable to the former with vs. I stode for shelter behinde that part of the wall of my house, which was left standing, till I feared it would fall upon me, and then shifted to another shelter, little better than the former.

About ten or eleven of the clocke, the winde ceased; but most part of the day was wet and rayney, very uncomfortable for those that had neither victuals to eat, dry cloathes to put on, or a house to shelter in, or fire to dry themselves by—which was the condition of most people. It was a deplorable sight to see the spoyle that was done in the canes and provisions, in comparison of which the losse of all our houses and workes is as nothing.

That day, although Sunday, I got up a little house, in whiche to secure myselfe and the best of my goods from the wet; and I used all diligence to gett up a couple of rooms, and one of my sugar-workes, and to put some Indian provisions in the ground, having thirty-two negroes, besides whites to feed every day (for which I blesse God). I was now indifferently well at my ease for the present; my two rooms being built, and everything indifferently well in order, towards the repaireing of my buildings and my other losses. When on Tuesday, the fourthe of October, after a very tempestuous night, about breake of day, a second hurricane began, which lasted until two or three in the afternoone. I used all the endeavours I could to secure my new house, where I was lodged. But all my endeavours were not sufficient, but that, about ten or eleven of the clocke, the roof was blown away over our heads all at once and carried many yardes from the house—and *that* in a very instant of time. But I thank God none of vs were hurt, but one who had a small hurt with a nayle in a board.

I made what haste I could out, and passed the remainder of the storme at the side of a wall, which afforded me some small shelter. This and the other hurricane were more fierce here and in another quarter, than in any other part of the island, as appeared by the effects of them. The damages done by this second storme, were very great, and would have been much more, had not the great spoyle wrought by the former hurricane deprived it of matter to worke upon. Though this was not so tedious, or exceedingly fierce as that, yet it hath destroyed our provisions, and hath occasioned a sickly and scarce time amongst vs. It was not violent at Antegoa, where severall ships were cast on shoar.

1733, *June*.—B. H.

1737, *September 9*.—B. H.

1747.—There were two violent hurricanes this year, one on September 21 and the other on October 24. They did great damage among

the Leeward Islands. Fourteen sail were lost at St. Kitts and 36 at the other islands.—S. C., Vol. 2, p. 305.

1765, September.—B. H.

1766.—This year seems to have been marked by an unusual number of direful calamities in the West Indies. An earthquake at Santiago de Cuba killed 40 persons, and at Grenada the same or another threw down the sugar works and hills in several places, so that it was impossible to ride round the island on horseback.

At 10 p. m. of August 13 a strong northwest gale set in at Martinique, and about midnight the shock of an earthquake added to the horrors of the increased hurricane. At 3 a. m. the storm abated, and daylight revealed a scene of desolation and woe; wrecks and dead bodies covered the shore at St. Pierre; the streets were covered with ruins, while the roads were blocked by trees uprooted by the storm and enormous stones brought down by the rivers. At 5 a. m. a water-spout burst upon Mount Peleus, overwhelming the neighboring plains. By 6 o'clock it was quite calm and the sea was smooth. As many as 90 persons are said to have perished, many of these under the ruins of their own houses, while twice that number were wounded. Seven English and 28 French vessels were wrecked; also 12 passage canoes.

On the 13th, 14th, and 15th of September such violent gales raged at St. Kitts and Montserrat that 13 vessels were wrecked at the former and all at the latter. At Montserrat half the town was destroyed and upward of 200 persons reduced to distress by the torrent from the mountains.

St. Eustatius suffered severely from a hurricane on September 21; the provision grounds and cane plantations were destroyed; several vessels lost. The salt works at Tortuga were destroyed by the hurricane, also, and 3 French and 5 Newfoundland vessels driven on shore.

On the 6th of October 5 vessels were driven on shore at Dominica in a gale of wind, and upward of 50 sail at Guadeloupe.

On the 22d and 23d of October a violent hurricane did considerable damage in the harbor of Pensacola. The Spanish fleet from Vera Cruz for Havana and old Spain, consisting of 5 large ships of register richly laden, were driven ashore at the Bay of St. Bernard.—S. C., vol. 2, p. 390.

1772.—During the last days of August and the first days of September a hurricane passed over the West Indies, causing frightful havoc among the Leeward Islands. At Dominica 18 vessels were driven ashore and lost. Several war ships were driven ashore at Antigua. At Montserrat and Nevis nearly every house was blown down. The hurricane passed over St. Kitts on August 31, beginning at daylight. At noon the storm abated to such an extent that the people thought that it was over, but the wind suddenly shifted from the northeast to the southwest by south, and blew with increased violence, destroying

almost every house, sugar mill, tree, and plant, killing several and wounding many persons. The damage was estimated at £500,000 sterling. At St. Eustatius 400 houses were destroyed or rendered untenable, and the Dutch church blown into the sea. At Saba 180 houses were blown down. At St. Martins nearly all the houses and all the plantations were destroyed. The disastrous effects of this storm were felt nowhere more forcibly than at Santa Cruz, where, it is said, the sea rose 72 feet above its usual height, carrying every ship at the island on shore, some as far as 100 yards inland. Large stones were brought down from the mountains, and there was a terrific electrical display. Four hundred and sixty houses were thrown down at Christianstadt and all but three at Fredericstadt. The magazines and stores were quite ruined. The total damage was estimated at \$5,000,000. The damage at St. Thomas was placed at \$200,000.—S. C., vol. 2, p. 411.

1772, November 22.—B. H., p. 23.

1775, October 16.—B. H., p. 23.

1776, September 5 to 6.—B. H., p. 23.

1780, August 25.—The devastations of this hurricane were so general that it is deemed best to reserve an account of the same for Chapter VIII, which see.

1785, August 25.—Great damage to shipping on account of severe hurricane.—Notes.

1792, July 14.—In consequence of a southerly gale, a ship with 500 hogsheads of sugar was driven on shore and dashed to pieces.—Notes.

1792, August 2.—A tremendous gale made almost general havoc among the shipping, the loss being universal, not only in property, but in lives.—Notes.

St. Kitts experienced a terrific flood, which caused the loss of many lives and the destruction of much property.—S. C., vol. 3, p. 62.

1793, August 12.—About 30 vessels were lost or stranded by a hurricane at St. Kitts.—S. C., vol. 3, p. 71.

1803, October 12.—Two American vessels were stranded by a southerly swell.—Notes.

1804, September 3.—Thirteen vessels were wrecked by a hurricane at St. Kitts. Among them was the *Aurora*, with cargo valued at 46,000 pounds sterling.—S. C., vol. 3, p. 307.

1806, October 28.—A southerly gale, accompanied by an awful thunderstorm, destroyed six small vessels.—Notes.

1807, July 25.—A southerly gale drove several vessels on shore, among them the ship *Maria*, with upward of 500 hogsheads of sugar, nearly all of which was lost.—Notes.

1813, July 22-23.—Two ships, four brigs, five schooners, and four sloops were driven on shore at night and stranded. Two seamen were drowned.—Notes; see also S. C., vol. 3, p. 521.

1815, July 25.—B. H., p. 24.

1816, *September 15*.—In consequence of an easterly gale all vessels put to sea. One sloop lost in the channel between this island and St. Eustatius; captain and two of the crew drowned.—Notes.

1817, *September 8*.—A strong southerly gale drove a sloop ashore.—Notes.

1818, *September 22*.—Strong westerly winds; no damage to shipping; one seaman drowned.—Notes.

1819, *September 21-23*.—A hurricane swept over the Leeward Islands, the Virgin Islands, and the Bahamas. It was first noticed near St. Lucia, passed over or near Antigua, St. Kitts, St. Bartholomews, and St. Martins. It was most destructive in the Virgin Islands. At St. Kitts it did considerable damage to the estates' works.—W. J. B.

1820, *August 28*.—Heavy winds from the south and west; ship *Pitt* ran ashore.—Notes.

1821, *September 9*.—A devastating hurricane from the southeast unroofed or seriously damaged dwelling houses, estates' works, and other buildings from one end of the island to the other. Canes were thrown flat and provisions destroyed. Many of the officers' quarters on Brimstone Hill were injured and buildings of minor importance shattered.—Notes.

1824, *September 7*.—A northeasterly gale drove two sloops aground. No damage on land.—Notes.

1825, *July 26*.—An east-southeast gale stranded one brig, one schooner, and three sloops. Four seamen were drowned. This storm was very severe at Guadeloupe, where the barometer fell 1.86 inches.—W. J. B.

1827, *August 17*.—A destructive hurricane, thought to be equal in violence to the "great hurricane" of 1772; houses in the town thrown down, dwellings and works seriously injured; tamarind and other trees which had withstood the ravages of time were torn up by the roots; several small vessels lost. A solemn fast and humiliation observed on the 31st.—Notes.

1829, *October 30*.—Southerly gale; five small vessels driven on shore; no damage on land.—Notes.

1830, *August 12*.—A slight blow; fences and trees thrown down; two sloops driven ashore.—Notes.

1831, *August 11*.—Heavy swell and southerly wind; five small vessels wrecked; two lives lost.—Notes.

1833, *August 14*.—Southerly wind and heavy sea; two or three small vessels driven on shore; no damage on land.—Notes.

1835, *August 12*.—Severest hurricane experienced for years; few premises escaped without some injury either in the dwellings, out-buildings, or fences; a few small houses in Basseterre destroyed; great loss of cattle; canes laid prostrate, and provision grounds dreadfully cut up; several deaths took place from bruises received from falling

timber. The damage sustained by the different barracks and buildings on Brimstone Hill was estimated at £3,000 sterling. Total loss from returns furnished by the vestries of the several parishes estimated at £80,000 sterling. At Antigua the barometer fell 1.4 inches at the rate of 1 inch in one hour and twenty-seven minutes.—W. J. B. and Notes.

1837, *August 2*.—A heavy wind from northwest shifting to the west threw a tremendous sea into the harbor. Two ships, 1 schooner, and 2 sloops driven on shore and wrecked; 1 seaman drowned. Not much damage on shore.—Notes.

1838, *November 13 (or 15)*.—Southerly wind, heavy swell, 2 sloops driven on shore.

1848, *September 19*.—B. H.

1851, *July 10*.—B. H.

1851, *August 16*.—B. H.

1852, *September 22*.—B. H.

1859, *September 2*.—The center of a rather mild hurricane passed over St. Kitts. A number of boats were wrecked besides other damage. It passed over St. Croix also.—W. J. B.

1871, *August 21*.—This was a very severe and destructive hurricane. The center passed over the island. The barometer began to show a downward tendency about 1 p. m. of the 20th, and by 1 a. m. of the 21st the fall became very decided, the wind being from the east-north-east. By 6 a. m. the barometer had fallen to 29.60, and the wind had shifted to the north; at 8.40 the barometer stood at 28.50 and there was a calm lasting twenty-two minutes, after which the wind came from the southwest and the barometer began to rise. The damage done was quite general. The center of this storm passed over Antigua and Statia (St. Eustatius?) also.—W. J. B.

The following memoranda relative to this storm are taken from a private meteorological journal kept by Mr. George James Evelyn, of Basseterre, and were made at the time of the hurricane, viz:

Date.	Hour.	Barometer.	Wind.	Remarks.
21st August, 1871	1.00 a. m.	29.80	ENE.	Squalls and short showers.
	3.00	29.74	ENE.	
	4.00	29.70	ENE.	Very strong wind.
	6.00	29.60	N.	Stormy.
	7.00	29.50	N.	Very heavy.
	7.30	29.40	N.	Tempest.
	8.00	29.27	N.	
	8.15	29.20	N.	Hurricane.
	8.20	29.10	N.	
	8.25	29.00	NW.	
	8.28	28.90	NW.	
	8.40	28.50	NW.	Dreadful.
	8.50	28.50	.....	A calm for 22 minutes.
	9.12	29.10	SW.	
	9.40	29.30	SW.	Good breeze and heavy sea.
	9.50	29.40	SW.	Strong.
	10.20	29.50	SW.	Very heavy sea.

1876, *September 12*.—The center of this hurricane passed to the north of St. Kitts, but made itself very severely felt thereat. The following notes are taken from Mr. Evelyn's journal:

Date.	Hour.	Barom-eter.	Wind.	Remarks.
11th	10.00 a. m.	30.03	E.	Good breeze; clear and fine; very hot.
	4.00 p. m.	30.00	E. and ENE.	Good breeze; clear and fine; splendid.
12th	10.00 a. m.	29.97	NE.	Strong breeze; threatening.
	4.00 p. m.	29.85	NE.	Very strong breeze; squally; bad.
	7.00	29.66	NW.	Do.
	7.36	29.57	NW.	Do.
	7.40	29.54	NW.	Very strong breeze; very heavy.
	7.45	29.50	NW.	Do.
	8.00	29.48	WNW.	Very strong breeze; very bad.
	8.45	29.35	WNW.	Wind changing to west; very heavy.
	9.30	29.40	WSW.	Very strong wind; heavy sea.
	9.45	29.46	WSW.	Do.
	10.30	29.60	WSW.	Do.
	12.30 a. m.	29.85	WSW.	Wind abating and less sea.
	2.00	29.90	SW.	Do.
	7.00	29.98	ESE.	Clear sky; good breeze; heavy sea; no thunder during storm; lightning in NW. and W-SW. at intervals.

1880, *January 12*.—This date is historic because of the occurrence of a most disastrous flood at St. Kitts. There stands in the cemetery at St. Kitts a plain massive monument with the following inscription, viz: "Sacred to the memory of those who perished in the flood in Basseterre, St. Christopher, on the 12th of January, 1880, and commemorative of that awful visitation, in which 231 persons lost their lives, of whom 101 are buried here." From eyewitnesses I learned a few additional facts and details concerning this event.

It appears that there were no premonitory signs of the impending disaster further than that toward sunset an unusual warmth was felt which continued up to 9 o'clock, when an "intense cold set in, followed by a light shower of rain." The clouds gathered early in the evening, quickly enshrouding the city in intense darkness: "The darkness could almost be felt." Occasional flashes of lightning, accompanied by "deep rumbling thunder," now and then relieved the painful feeling. About 11 o'clock the rain began again and, it is said, it looked as if sheets of water were pouring out of the clouds. Soon the place was flooded, and ere long the water began to creep into the houses, to the great consternation of the inmates, who, upon attempting to escape, found the streets like rivers, making egress not only unsafe but well-nigh impossible. Those who were so fortunate as to possess an upstairs availed themselves of the security afforded by a more elevated position, but unfortunately the bulk of the people lived then as now, in small one-story, one-roomed huts built of light material and loosely put together, so that houses and all soon began to move seaward. The rain continued for about three and a half hours, resulting, as above stated, in the drowning of 231 persons, perhaps more, and the loss of much property. Many persons were buried beneath a layer of mud

several feet deep, brought down by the waters from the hillsides and neighboring estates.

Of course, all gauges and marks by which the amount of the precipitation could be measured were either swept away or entirely submerged, and only individual opinions can now be had on this point. I find this note in Mr. George James Evelyn's journal, viz:

It is supposed that 36 inches fell during the time from 12 o'clock (midnight) to 3 a. m., 13th. Town flooded; immense damage to houses; many persons lost and missing.

There are some who estimate the fall as low as 23 inches. It was this heavy fall in the town, augmented by the overflowing of the mountain streams, which caused this great havoc in the city of Basseterre.

1881, August 21.—This hurricane did very little damage in St. Kitts.

1889, September 2.—In regard to this hurricane as it affected St. Kitts, Dr. W. J. Branch writes me as follows, viz:

I was in Scotland when the hurricane of September 2, 1889, occurred. Mr. Cable tells me that it was first reported from Dominica, and that it struck St. Croix after leaving St. Kitts. It blew the steamship *Roraima* ashore. I found her on the rocks at Rawlins when I came home in November. From the account given to me, there is no doubt that the hurricane center passed over St. Kitts, for there was a distinct calm in the middle of it of twenty or more minutes' duration, but it seems to have been a mild specimen of the cyclone genus.

1898, September 12.—The hurricane passed the island with only a slight brush, doing no damage.—Monthly Weather Review, September, 1898, p. 394.

1899, August 7.—The day preceding the hurricane was the warmest of the season thus far, the temperature reaching a maximum of 88°, and the afternoon was characterized by gusty, whirling winds from the northeast, with an occasional momentary calm, and by a hazy atmosphere, with strato-cumulus clouds moving from the east rather rapidly and above which there seemed to be a thin sheet of cirro-stratus, through which the sun shone with a pale, sickly light. The sea was wonderfully clear, so much so that one could see very distinctly the stones on the bottom, but gave no sign of unusual agitation. The sunset was not marked by saffron skies, nor did the barometer, up to this time, show the slightest tendency to depart from its normal condition. At 3.30 p. m the wind set in steadily from the northeast at the rate of 12 miles per hour, with a gradually increasing force. At 10 p. m. the barometer began to fall, and the wind, still increasing in force, had attained a velocity of 18 miles per hour. By 3 a. m. of the 7th the barometer dropped 0.01 inch, and the wind was blowing at the rate of 24 miles per hour, and there was an apparent tendency to cloudiness, so that by 5.30 a. m. the sky was almost entirely overcast with low clouds, from which frequent showers fell.

The storm came from the southeast and moved toward the northwest, the center passing a little south of the island. The barometer

reached its lowest reading at 5 p. m., seventy-fifth meridian time, when it stood at 29.268 inches. After this hour it began to rise rather gradually.

The wind continued from the northeast until about 6 p. m., when it veered to the east, where it remained until about 8 p. m.; it then changed to the southeast, and so continued to the end of the storm. The verifying velocity (45 miles per hour) began at 2.34 p. m. and ended at 12.25 a. m. of the 8th; the storm therefore lasting nine hours and fifty-one minutes. The maximum velocity (the greatest velocity for any five minutes) was 72 miles per hour, and occurred between 4.22 and 4.27 p. m. The extreme velocity (1 mile in the shortest time) occurred at 4.40 p. m., when the wind blew a mile in one-half minute, or at the rate of 120 miles per hour. The total wind movement during the storm was 478 miles, as follows, viz: From the northeast, 196; from the east, 112, and from the southeast, 170. The hurricane was accompanied by a light rain, the total amount of which was 1.28 inches. The heaviest fall occurred between 4.53 p. m. and 5.10 p. m. There was neither thunder nor lightning during the storm.

So far as known there was no loss of life at St. Kitts, but the property loss was considerable. A number of very substantial buildings were blown down, many huts entirely destroyed, and the canes badly damaged.

(For fuller details see Monthly Weather Review for August, 1899, p. 345.)

1899, September 8.—This hurricane, as compared with that of August 7, was slightly less intense, and far less disastrous, owing, no doubt, to the fact that only the strong trees and buildings were left, and these were able to resist successfully the attacks of the feebler storm.

The hurricane began at 3.40 p. m. and ended at 2.25 a. m. of the 9th, lasting, therefore, ten hours and forty-five minutes, during which time there was a total wind movement of 514 miles, or an average of 48 miles per hour during the entire storm. The maximum velocity of the wind was 62 miles, and occurred between 8.18 and 8.23 p. m. The extreme velocity was 120 miles per hour, at 5.51 p. m.

The lowest reading of the barometer, 29.506, occurred at 5 p. m., and the wind came from the southwest during the entire storm. The total rainfall was 3.13 inches, the heaviest fall being during the first two hours of the storm.

A few small huts were destroyed, rendering about 200 people homeless; two schooners with cargoes, total value \$25,000, were wrecked; one small boat, valued at \$240, wrecked. The cane crop suffered the greatest injury because of the fact that the storm of August 7 blew the canes from the northeast and this one from the southwest, thus almost twisting them out of the ground.

CHAPTER VIII.

BRIEF HISTORICAL NOTES ON REMARKABLE WEST INDIAN HURRICANES AND EARTHQUAKES.

We present in this chapter some notes relative to events occurring in the West Indies since their discovery. Much more might be said of the storms of recent years, but full and accurate accounts of these are accessible to almost everyone, hence a reproduction of these is unnecessary. The authority for each note is given (the abbreviations are the same as for the preceding lists). Many of these notes have also been published in Bulletin H of the Weather Bureau.

1492.—While coasting along the north coast of Cuba Columbus was driven by violent gales 56 leagues to the northeast. He was also compelled to remain in harbor off Espanola some days because of “stress of weather.”—S. C., vol. 1, p. 12.

1493.—On returning to Spain Columbus and his fleet were overtaken by a severe storm on February 12, which lasted three days and threatened them with certain destruction, so much so that Columbus wrote an account of his discoveries and threw it overboard.—S. C., vol. 1, p. 17.

1494.—While on his second voyage Columbus anchored at Cape Santa Cruz, and while there, “upon the 16th July a violent hurricane occasioned the admiral to declare that nothing but the service of God and the extension of the monarchy should induce him to expose himself to such dangers.”—S. C., vol. 1, p. 35.

1498.—When 480 miles southwest of the Cape Verde Islands, Columbus found that “the altitude of the north star was five degrees.” Here, in a calm, he expected that the heat would set the vessels on fire; the men were alarmed and dared not go below, though the stores were spoiling. This weather lasted eight days; the first only was clear, the seven following it rained; had all been as hot as the first, Columbus says nothing could have saved them.—S. C., vol. 1, p. 51.

1502.—While searching for a passage to the South Sea Columbus arrived off Santo Domingo and asked permission to enter the harbor which was refused. His object in entering the harbor was to exchange his vessel and to find shelter from a hurricane which Columbus thought was approaching. The fleet sailed July 1 and within twenty-four

hours twenty sail with all on board perished. Columbus said: "The gale was terrible, and in that night my vessel parted company, every one expecting death, and each considering it certain that the others were lost. With the exception of Job there never was a man who would not have died in despair: When to save my life and that of my son, brother, and friends, I was at such a time forbidden the harbors, which, by God's permission, I had gained for Spain, sweating blood. The vessel in which I was, weathered the gale marvelously; it pleased God that she received no damage whatever. My brother was in the unsafe vessel, and, next to God, was the means of saving her. In this gale we made Jamaica."—S. C., vol. 1, p. 76.

1508.—On the 3d of August all the thatched houses in Santo Domingo, and several of those built with stone, every house in Bonaventura, and twenty sail of vessels, were destroyed by a hurricane. At first the gale blew from the north, then shifted suddenly to the south.—S. C., vol. 1, p. 107.

1509.—On July 10, Admiral Don Diego Columbus arrived at Santo Domingo with his bride, and a few days later almost the entire city was destroyed by a hurricane. These visitations were considered marks of divine displeasure.—S. C., vol. 1, p. 109.

1526.—In October a violent hurricane did great damage in the island of Española; rivers overflowed their banks. No such had been experienced in that island for many years.—S. C., vol. 1, p. 156.

1530.—There was great distress among the inhabitants of San Juan because of a hurricane, which was followed by rainstorms, so that the rivers were overflowed, crops, trees, and herds were washed away; the works at the gold mines and other undertakings were suspended.—S. C., vol. 1, p. 167.

1591.—On July 17 a fleet of 77 sail left Havana for Spain, and on August 10, in latitude 35° north they were overtaken by a gale and the commander of the fleet with 500 men perished. Three or four days later, in another gale, five or six of the largest ships with all their crews and the vice-admiral were lost. About the end of August, in latitude 38°, they experienced another gale during which 22 sail perished. September 6 the remaining 48 arrived within sight of Flores, where they were separated by another gale, so that of the 123 sail that were expected in Spain this year from the West Indies but 25 arrived.—S. C., vol. 1, p. 212.

1635.—Du Pont, while on his way from Martinique to St. Kitts to bear the news of a treaty of peace between himself and the Caribs to D'Enambuc, was driven by a violent gale to the coast of Española, where he was taken prisoner by the Spaniards and closely confined for three years.—S. C., vol. 1, p. 275.

1656.—The island of Guadeloupe was desolated by a fearful hurricane. Most of the houses were destroyed, all the domestic animals

were killed, and all the plantations laid waste. Every vessel at anchor in the roads was wrecked and most of their crews drowned.—S. C., vol. 2, p. 14.

1664.—The crop of potatoes was destroyed by a violent hurricane at Guadeloupe. An earthquake at St. Kitts did considerable damage.—S. C., vol. 2, p. 53.

1666.—On August 4 a hurricane began at Guadeloupe at 6 p. m., the wind blowing from the north. It continued with great violence until midnight, when there was a calm of a quarter of an hour, the wind then shifting to the south and driving everything before it with irresistible force. Every vessel and boat on the coast of Guadeloupe was dashed to pieces—all the vessels in the Saints were driven on shore—and of Lord Willoughby's fleet (consisting of 17 sail with 2,000 troops) only two were ever heard of afterwards. An *armée en flute* of 22 guns got to Montserrat with only the stump of her mizzenmast standing, and a fire ship got to Antigua dismasted. The bottom of one ship was washed on shore at Cabsterre, Guadeloupe, and another at the Saints. The whole coast was covered with wrecks of masts and yards. A figure from the stern of Lord Willoughby's ship was recognized among the ruins. The hurricane lasted twenty-four hours; houses and trees were blown down, and a great number of cattle killed. The sea rose and was driven to an unusual height. All the batteries—walls of 6 feet thickness—near the sea were destroyed and guns—14-pounders—were washed away. The storm was felt at St. Christopher and Martinique, but with less violence.—S. C., vol. 2, p. 70.

1674.—At Barbados, on the 10th of August, a hurricane blew down 300 houses, killing 200 persons; wrecked eight ships in the harbor, and so damaged the plantations that very little sugar was made the two succeeding years.—S. C., vol. 2, p. 110.

1675.—The island of Barbados was again devastated by a hurricane in August of this year. The crops were destroyed, and the people asked the British Government to relieve them of an impost of $4\frac{1}{2}$ per cent on exports. This was refused.—S. C., vol. 2, p. 111.

1681.—The island of Antigua was desolated by a tremendous hurricane.—S. C., vol. 2, p. 121.

1689.—A dreadful mortality swept away one-half the inhabitants of Nevis.—S. C., vol. 2, pp. 146, 149.

1690.—The island of Antigua was almost desolated by an earthquake.—S. C., vol. 2, p. 158.

1692.—Jamaica suffered from a dreadful earthquake on June 7, between 11 and 12 o'clock noon. The town of Port Royal was almost completely destroyed in less than three minutes. About 3,000 of the inhabitants with their houses found one common grave. The sinking of the wharfs was but a prelude to that of the town; those nearest the water first disappeared; the next in succession followed. In the meanwhile the streets began to gape, "opening those dreadful fissures into

which the miserable remnant of the inhabitants fell who had escaped the previous ruin and were fleeing for shelter in the open air." The water began to roll where the town had flourished, and swept from sight the devastations which the earthquake had made. Several of the inhabitants were swallowed up and returned again to the surface of the earth through distant apertures which had no visible connection with those which first yawned to receive them. Some were returned alive and even without material injury. The waters rose and filled the houses which had survived the shock, to the upper story—"a preternatural tide that was to ebb no more." Some of the streets were laid several fathoms deep under water; the harbor was agitated as in a storm. The ships parted their cables. The *Swan* frigate lay by the wharf, and was forced over the tops of the sunken houses, and saved some hundreds of the inhabitants. The fort and about two hundred houses escaped; but part of the neck of land, about a quarter of a mile in length, was entirely submerged, with all the houses, which stood very thick upon it.

A general sickness ensued, which, with the other miseries, left the island almost destitute. The assembly ordered a perpetual anniversary fast in commemoration of this calamity.—S. C., vol. 2, p. 161.

1722.—The town of Port Royal, Jamaica, was visited by a severe hurricane on the 28th of August, in which 26 merchant vessels were wrecked and 400 persons killed. An eyewitness says:

The hurricane began at 8 in the morning, two days before the change of the moon. It gave at least forty-eight hours, notice by a noisy breaking of the waves upon the keys, very disproportioned to the breeze, a continued swell without reflux of the water, and the two nights preceding, prodigious lightning and thunder, which all the old, experienced men foretold would be a hurricane, or that one had already happened at no great distance. The wind began in flurries from the northeast and flew quickly round to the southeast and south-southeast, where it continued, the stress of the storm, bringing such quantities of water that our little island was overflowed 4 feet at least; so that with the fierce driving of shingles about our ears, and the water floating boats, empty hogsheads, and lumber about the streets, those without doors were every moment in danger of being knocked on the head or carried away by the stream. Within it was worse, for the waters sapping the foundations, gave continual and just apprehension of the houses falling, as in effect half of them did, and buried their inhabitants. * * * The whole rise of the water was computed at 16 or 18 feet at a place where it is not ordinarily observed to flow above 1 or 2. At 5 in the evening the waters abated, and so quickly as to leave the streets dry before 6. * * * Wrecks and drowned men were everywhere seen along shore; general complaints of loss at land, which made it a melancholy scene; and to finish the misfortune, the slackness of the sea breeze, calms, lightning, stagnating waters, broods of insects thence, and a shock or two of earthquake that succeeded the hurricane combined to spread a baneful influence, and brought on a contagion fatal for some months through the island.

B. Edwards says that as upon the same day of the month ten years before another hurricane had shaken the island, the anniversary of the day was, by an act of the assembly, set apart for fasting and humiliation.—S. C., vol. 2, p. 223.

1737.—On September 9 the town of St. Louis, St. Domingo, was destroyed by a hurricane. All the sugar cane and cotton trees were destroyed and all the ships in the harbor were thrown upon the coast. This hurricane did great damage at St. Kitts and Montserrat. At the latter island it blew down all the windmills and houses and carried away mules, negroes, and cattle into the sea. The sugar canes were all destroyed.—S. C., vol. 2, p. 264.

1744.—On the 20th of October, at Jamaica, a dreadful hurricane began at 6 p. m. and lasted until 6 the next morning; the wind was all that time due south. Mosquito fort was demolished. Eight English ships and vessels and 96 merchant vessels were stranded and foundered. Out of 105 vessels only one, the *Ripon*, rode out the gale and she without masts. One hundred and eighty-two men were drowned.—S. C., vol. 2, p. 301.

1754.—A hurricane in September did great damage at St. Domingo to the sugar and indigo plantations. Twelve ships were driven ashore and 1,700 hogsheads of sugar lost.—S. C., vol. 2, p. 317.

1759.—“In the month of September a heavy gale of wind from the northeast so greatly impeded the current of the Gulf stream that the water forced at the same time into the Gulf of Mexico by the trade winds rose to such a height that not only the Tortugas and other islands disappeared, but the highest trees were covered on the peninsula of Larga; and at this time (so says Wm. Gerard de Brahm esq.), the snow, “*Litbury*, John Lorrain, master, being caught in the gale, came to an anchor, as the master supposed, in Hawke Channel; but to his great surprise found his vessel the next day high and dry on Elliotts Island, and his anchor suspended in the boughs of a tree.”—S. C., vol. 2, p. 336.

1761.—On the 31st of March, at 4 p. m., the sea at Barbados began to flow; at 8 it appeared to ebb; but at 10 it increased considerably and continued so until 6 the next morning. A similar agitation in the water was observed there at the time of the earthquake at Lisbon in 1755.—S. C. vol., 2, p. 343.

1762.—A storm from the southward followed by an earthquake destroyed a great part of the walls surrounding the town of Carthage on December 9; wrecked many houses, among them the castle of Santa Maria; drove two Spanish men-of-war on shore.—S. C., vol. 2, p. 345.

1768.—On the 25th of October a brief but violent hurricane occurred at Havana. The storm began from the south and died away from the north, having continued not more than two hours; nevertheless, in that short time, 98 public buildings and 4,048 houses were destroyed, and above 1,000 persons killed almost instantly.

It was this year that the snow ^a *Rodney*, carrying convicts to Maryland, was forced by stress of weather into Antigua. It is also stated

^a A two-masted square-rigged vessel.

that there was great distress among the convicts, as many as 11 died from want, and the survivors had to eat their shoes and the like to sustain life.—S. C., vol. 2, p. 398.

1770.—On the 3d of June, in the afternoon, the island of St. Domingo suffered from a fearful earthquake. The city of Port au Prince was entirely destroyed; not one house was left standing, and more than 500 people were buried beneath the ruins. La Croix de Bouquet, a small town, with the greater part of the inhabitants, was swallowed up. The sea rose a league and a half in the island.—S. C., vol. 2, p. 407.

1771.—The great calamity of this year came in the form of a famine at the Bay of Honduras, caused, it is said, by locusts. They ate up every green thing, and in some places covered the ground a foot thick. It was estimated that as many as 80,000 Indians died from starvation because of this awful visitation.—S. C., vol. 2, p. 408.

1779.—This year was marked by a drought and famine at Antigua. The water supply became quite insufficient and the stock and negroes perished in the greatest agony. A malignant fever raged at the same time, threatening all with death. Mr. Baxter, a Methodist preacher, appointed the 28th day of May as a day of fasting, and he says: "It is remarkable that while we were assembled for prayer the Lord granted our request by sending an abundance of rain."—S. C., vol. 2, p. 459.

1780.—The following data relative to the great hurricane of this year are taken from Southey's Chronology, pages 467 to 476.

The hurricane began at Barbados on the morning of the 10th of October, and continued with little intermission about forty-eight hours. In the afternoon of the first day all the ships were driven from their anchors to sea. In the course of the night Bridgetown was nearly laid level with the earth. Daylight presented a scene of desolation seldom equalled; not one house or building in the island, however strong or sheltered, was exempt from damage. Most of the live stock and 4,326 persons perished; the loss which the colony sustained was estimated at 1,320,564 pounds sterling. Upon the authority of a public document sent to the secretary of state by the governor of the island, it is said that a 12-pound gun was by the wind and waves carried from the south to the north battery, a distance of 140 yards. Some Spanish prisoners, under Don Pedro St. Jago, assisted the troops in relieving the inhabitants and preventing the negroes from plundering.

Parliament voted 80,000 pounds sterling for the relief of the sufferers.

Major-General Cunninghame, governor of Barbados, sent the following account of the hurricane at that island to the secretary of state and Major-General Vaughan. The commander in chief refers the English Government to that account for a description of it:

"Copy of a journal of what passed at Barbados, from the 9th of October until the 16th.

"The evening preceding the hurricane, the 9th of October, was remarkably calm, but the sky surprisingly red and fiery; during the night much rain fell. On the morning of the 10th much rain and wind from the NW. By 10 o'clock it increased

very much; by 1 the ships in the bay drove; by 4 o'clock the *Albemarle* frigate (the only man-of-war here) parted her anchors and went to sea, as did all the other vessels, about twenty-five in number. Soon after, by 6 o'clock, the wind had torn up and blown many trees, and foreboded a most violent tempest. At the Government house every precaution was taken against what might happen; the doors and windows were barricaded up, but it availed little. By 10 o'clock the wind forced itself a passage through the house from the NNW., and, the tempest increasing every minute, the family took to the center of the building, imagining, from the prodigious strength of the walls—they being 3 feet thick—and from its circular, it would have withstood the wind's utmost rage; however, by half past 11 o'clock they were obliged to retreat to the cellar, the wind having forced its way into every part, and torn off most of the roof. From this asylum they were soon driven out, the water being stopped in its passage, and having found itself a course into the cellar, they knew not where to go; the water rose 4 feet, and the ruins were falling from all quarters. To continue in the cellar was impossible; to return to the house equally so; the only chance left was making for the fields, which at that time appeared equally dangerous; it was, however, attempted, and the family were so fortunate as to get to the ruins of the foundation of the flagstaff, which soon after giving way, every one endeavored to find a retreat for himself. The governor and the few who remained were thrown down, and it was with great difficulty they gained a cannon, under the carriage of which they took shelter. Their situation here was highly deplorable; many of the cannon were moved, and they had reason to fear that under which they sat might be dismounted and crush them by its fall, or that some of the ruins that were flying about would put an end to their existence; and to render the scene still more dreadful they had much to fear from the powder magazine, near which they were. The armory was level with the ground and the arms, etc., scattered about.

"Anxiously did they wait the break of day, flattering themselves that with the light they would see a cessation of the storm; yet when it appeared little was the tempest abated, and the day served but to exhibit the most melancholy prospect imaginable. Nothing can compare with the terrible devastation that presented itself on all sides—not a building standing; the trees, if not torn up by the roots, deprived of their leaves and branches, and the most luxuriant spring changed in this one night to the dreariest winter. In vain was it to look around for shelter. Houses that, from their situation it was to have been imagined would have been in a degree protected, were all flat with the earth, and the miserable owners, if they were so fortunate as to escape with their lives, were left without a covering for themselves and family. General Vaughan was early obliged to evacuate his house. In escaping he was much bruised. His secretary was so unfortunate as to break his thigh.

"Nothing has ever happened that has caused such universal desolation. No one house in the island is exempt from danger. Very few buildings are left standing on the estates. The depopulation of the negroes and cattle, particularly of the horned kind, is very great, which must, more especially in these times, be a cause of great distress to the planters. It is as yet impossible to make any accurate calculation of the number of souls who have perished in this dreadful calamity—whites and blacks together, it is imagined to exceed some thousands; but fortunately few people of consequence are among the number. Many are buried in the ruins of the houses and buildings, many fell victims to the violence of the storm and inclemency of the weather, and great numbers were driven into the sea and there perished. The troops have suffered inconsiderably, though both the barracks and the hospital were early blown down. Alarming consequences were dreaded from the number of dead bodies that lay uninterred, and from the quantity the sea threw up, which, however, are happily subsided. What few public buildings there were are fallen in the general wreck. The fortifications have suffered very considerably. The buildings were all

demolished, for so violent was the storm here, when assisted by the sea, that a 12-pounder gun was carried from the south to the north battery, a distance of 140 yards. The loss to this country is immense. Many years will be required to retrieve it."

The hurricane nearly ruined the Spanish fleet under the command of Don Bernardo de Galvez. Four capital ships, besides others of different denominations, were totally lost, and all on board, above 2,000 persons, perished. The remainder of the shattered fleet got to the Havana.

At St. Lucia only two houses were left standing in the town. His Majesty's sloop *Badger* was dismasted and driven ashore in the harbor. All the barracks, huts, and other buildings were blown down, and all the ships were driven to sea.

At St. Christopher several vessels were driven on shore.

Considerable damage was done at Dominica.

Every building in St. Vincent was blown down. The *Experiment*, of 50, and the *Juno*, a French 40-gun frigate, were entirely destroyed.

At Grenada nineteen sail of loaded Dutch ships were stranded and beat to pieces. The dreadful hurricane, which proved so calamitous to many of the islands, produced in Grenada the effect which the legislature had offered £20,000 to have accomplished: The sugar ants disappeared in an instant before the violence of this tornado.^a

At Martinico,^b on the 12th, four ships foundered in Fort Royal Bay and every soul perished. Every house in St. Pierre was blown down, and more than 1,000 persons perished. At Fort Royal town, the cathedral, seven churches, the governor's house, the senate house, the prisons, the hospitals, the barracks, and upward of 1,400 houses were blown down. In the hospital of Notre Dame, 1,600 patients, with the nurses and attendants, were almost all of them buried in the ruins. In the shipwrights' sick house 100 perished. Upward of 9,000 persons were computed to have perished in the island, and the damage estimated at 700,000 louis-d'ors.

At St. Eustatia,^c on the 10th, at 11 p. m., the sky suddenly blackened all around; it rained violently, and thundered and lightened. In the forenoon the gale increased; seven homeward-bound ships were dashed to pieces and every soul on board perished; nineteen others were driven to sea. In the night every house to the northward and southward was blown down, or washed away, with the inhabitants, into the sea. Some few who had hid themselves in large holes in the mountain were saved. In the afternoon of the 11th the wind shifted suddenly to the eastward and swept every house to the east and west. Between 4,000 and 5,000 persons perished, and the damage was estimated at £150,000. The cathedral and four churches, and the barrack and hospital were left standing.

1781.—On the first of August at Jamaica a gale of wind from the south sunk two loaded vessels and drove 24 others on shore, besides wrecking or driving on shore 73 light vessels.—S. C., vol. 2, p. 499.

1784.—A hurricane began at Jamaica at 8.30 p. m. and continued up to, or later than, 11 p. m. of July 30, sinking, dismasting, or driving on shore every vessel in the harbor except four, causing the loss of numerous lives. The barracks were blown down, killing 5 soldiers. The workhouse was destroyed and 10 of the inmates killed or wounded. During the first three days of August the island of St. Domingo experienced a storm.—S. C., vol. 3, p. 3.

^aThis is an early example of the misuse of the word tornado.

^bNow Martinique.

^cSaint Eustatius.

1785.—A hurricane visited Jamaica on the 27th August.—S. C., vol. 3, p. 7.

1786.—The first storm of this year occurred in August doing most damage at St. Eustatius, where all the shipping was driven to sea and most of the small craft destroyed. It also swept the southern coast of Espanola. Another hurricane swept over Guadeloupe on September 10, doing much damage. On Saturday, the 2d of September, an alarming hurricane threw the inhabitants of Barbados into the utmost consternation. At 11 p. m., when the storm was at its height, a meteor in the southeast issued from a dark cloud, and spreading its diverging rays to a vast circumference, continued, with unabated splendor, near forty minutes.

In the morning of the 3d Carlisle Bay was a scene of desolation; not a vessel had ridden out the storm. In the country great damage was done to houses and crops; many persons killed in the ruins of their own houses.

Jamaica came in for her share this year on the 20th October. The trees were stripped of their leaves and appeared as if fire had passed over them. The shores were covered with aquatic birds killed by dashing themselves against mangroves.—S. C., vol. 3, p. 11.

1787.—According to the record there were three gales at Dominica this year, all in August—one on the 3d, one on the 23d, and one on 29th. A number of houses, all the barracks, and all the vessels in the harbor were wrecked.

In September, on the 23d, Balize experienced a severe hurricane, attended by heavy rains, and as the sea rose the land floods could not flow off, hence great damage was done by the overflow. It is stated that more than 500 persons were thrown down and 100 perished. Dead carcasses and logs of mahogany were floating about in every direction. As many as 11 square-rigged vessels, besides smaller ones, were totally lost.—S. C., Vol. 3, p. 13.

1790.—The little island of Tobago is brought into notice this year by destruction wrought there in August by a hurricane which, among other things, wrecked 20 vessels on the coast. As illustrative of the marvelous things sometimes performed by the hurricane we reproduce an account of what occurred on Mr. Hamilton's estate during this gale. "His new mansion, which had been built upon pillars, was lifted by the tempest and removed to some distance; but, being well made, did not go to pieces. Mrs. Hamilton, two ladies, and five children were in the house and suffered little or no harm. Mr. Hamilton, being absent from home, knew not what had happened; but, returning in the night, which was excessively dark, and, groping for his door, fell over the rubbish left on the spot, and so far hurt himself that he was confined for a week."—S. C., vol. 3, p. 38.

1791.—At daybreak, the 21st of June, it began to rain near the

Havana and continued until half-past 2 in the afternoon of the following day with such force as to cause the greatest flood ever remembered in that country. The royal tobacco mills and the village in which they stood were washed away, and 257 of the inhabitants killed. In the spot where the mills stood, the water, or a partial earthquake, opened the ground to the depth of 45 feet, and in one of the openings a river appeared of the purest water. Where the Count Baretto's house stood was a cavity more than 60 feet deep from which a thick smoke rose. Four leagues from thence the torrent was so great that none of the inhabitants within its reach escaped. All the crops of corn and growing fruits were carried away. Three thousand persons and 11,700 head of cattle are said to have perished in the flood.—Southey, *C.*, vol. 3, p. 48.

. 1806.—Southey's *Chronology*, vol. 3, p. 365:

[From the *Dominica Journal*, September 20, 1806.]

ROSEAU, *September 20.*

We again resume our journal, after an interruption occasioned by the confusion and loss sustained in the office during the late hurricane, one of the greatest calamities this colony has sustained within the memory of its oldest inhabitants. To give a detail of all the particulars of that unfortunate event would be a task impossible to fulfill with accuracy, until things commence to be a little more settled, and that a regular communication with the country should be opened, the roads being entirely destroyed. We shall therefore confine ourselves chiefly to the giving a general idea of the whole, as far as the intelligence received from the different parts of the colony may enable us.

On Tuesday the 9th instant, about 7 o'clock in the evening, the sky became totally overcast, and tremendous flashes of lightning, accompanied by heavy puffs of wind, presaged to the more experienced part of the inhabitants an approaching storm; but few expected it would have been so fatal in its consequences. The wind continued increasing until 10 o'clock, when it began to be accompanied by a most dreadful fall of rain, the effect of which, accompanied by a pitch-like darkness, each moment illuminated by a sheet of livid fire, and the roaring of the wind, which every instant became louder, was awful enough to impress a dread upon the heart of the most intrepid. Soon after, to complete our misfortune, the river Roseau, increased by the heavy rains, overflowed its banks, inundated the town in every direction, and then the destruction became general. Every house which obstructed its passage was thrown down, or carried away by the stream, and a great proportion of their unfortunate inhabitants perished. About 10 o'clock every vessel in the harbor was driven from its moorings, except a small Swedish schooner, which was cast ashore under the fort a little after midnight; and those which were driven out generally met with the same fate, amounting in the whole, to 16 sail, of different descriptions.

No pen can paint the horrors of that dreadful night; the tremendous noise occasioned by the wind and rain, the roaring of the waters, together with the shock of an earthquake, which was sensibly felt about midnight; the shrieks of the poor sufferers crying for assistance; the terror of those who in their houses heard them and dared not open a door or window to give succor, and who expected momentarily to share the same fate, formed a scene which can hardly be conceived and still more difficult to be described. Fortunately for the inhabitants of the town, and, indeed, for the whole colony, the force of the wind and rain abated about 3 o'clock in the

morning and near the same time the water began to fall. If it had continued another hour there is not a doubt that the town would have been destroyed.

The spectacle which presented itself on the return of daylight was horrid beyond every power of description. Heaps of mud and sand (in some places 5 or 6 feet deep) through all parts of the town; the form of a street hardly to be discerned; two large streams, or rather torrents, running through the midst of the town; ruins of houses blown down and others brought down by the flood, obstructing every passage; the carcasses of several of the unfortunate victims of this event drawn out from the ruins and lying in the streets, while numbers almost distracted were searching for some near relation or friend who had perished in the storm; the lamentations of those who had lost some of their nearest and dearest connections, joined to the despair of those who had lost their little all, formed together a scene fit to draw tears from the eyes of the most unfeeling.

From the most authentic accounts which have been gathered during the confusion occasioned by this fatal occurrence there has been ascertained to have perished in the town of Roseau and its vicinity 8 white persons of different sexes and ages, 57 free persons of color, and 66 slaves, forming a total of 131, besides numbers of others yet missing, and several wounded.

On Morne Bruce, where that part of the garrison stationed at Roseau is quartered, the whole of the barracks were blown down excepting one. Three men and 1 woman killed, and 1 man wounded.

The planters have equally suffered with the inhabitants of the town. Every plantation on the windward coast of the island from the River Tabarie to Morne Paix Bouche are almost entirely destroyed, only 3 mills standing in the whole extent, and these considerably damaged. No other building left on the sugar or coffee estate, and the numerous inhabitants of that quarter have only for shelter 4 houses situated some distance from the sea, to which most of the white inhabitants have retired. On the different estates on that coast, as far as accounts have reached town, there have perished about 30 negroes and upward of 180 dangerously wounded. Round the coast from River Tabarie, by way of La Soye, the estate which bears the name of that river is perhaps the only one which has not received any considerable damage in this general disaster.

All the plantations to leeward of the island have experienced the effects of the hurricane. Every house from the River Mahaut down to Prince Rupert's either flat or greatly damaged, the town of Portsmouth entirely destroyed, the greatest part of the barracks on Morne Cabrit carried away, and, in general, the whole island offers a scene of devastation and ruin.—S. C., vol. 3, p. 365.

1807.—The Bahama Islands were so desolated by "hurricanes that the inhabitants suffered great hardships in procuring the necessaries of life."—S. C., vol. 3, p. 393.

1812.—October 14 a hurricane devastated Trinidad, Cuba, wrecking 500 houses and very much damaging the Pope's Convent and the hospitals, besides driving on shore or sinking many of the vessels in the harbor of Casilda.—S. C., vol. 3, p. 519.

1813.—The island of Dominica suffered considerably from two hurricanes which succeeded each other within a short time. Several houses were blown down. To add to the calamities of the inhabitants upward of 500 runaway negroes made nightly incursions from the mountains, and, by acts of rebellion, threatened the destruction of the colony.—S. C., vol. 3, p. 521.

1815.—The West Indian Islands, especially the Leeward Islands, desolated by a hurricane which swept over them on August 31 and September 1. It is said that 30 sail were driven on shore at St. Bartholomew alone and 14 totally lost.

A hurricane, on September 20, blew down or unroofed about half the houses in Turks Island besides destroying about 400,000 bushels of salt. A number of vessels were wrecked, and one American vessel lost 22 of her crew and passengers.

On the 28th of October Jamaica suffered very great damage from a hurricane. Several vessels with their crews were lost and others damaged.—S. C., vol. 3, pp. 608, 610.

1859.—On September 2 a hurricane of rather mild form passed over St. Kitts—that is, the center passed right over the island. It wrecked a number of boats, besides other damage. It passed over St. Croix after leaving St. Kitts.—DR. W. J. BRANCH.

1899.—The great hurricane of this year was the one which occurred in August, between the 7th and 14th. It was so violent and caused such widespread destruction that it will certainly be ranked as a historical hurricane, for which reason it is mentioned in this place. Entering the West Indian regions in the vicinity of Guadeloupe, it included in its majestic sweep the Leeward and Virgin Islands, Porto Rico, and the Bahamas, not to mention the damage along the coast of the United States. The desolation and ruin wrought by this monster in the West Indies are fresh in the minds of all and need not be repeated here. This hurricane was peculiar in that it maintained a distinct organized existence for more than a month, finally dissipating in the region of the Mediterranean Sea.—W. H. A.

